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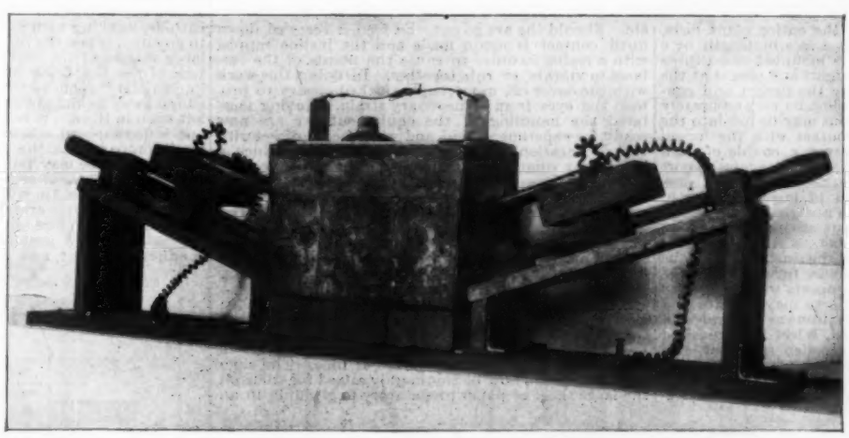
THE UTILIZATION OF 110 VOLT ELECTRIC CIRCUITS FOR SMALL FURNACE WORK.

ACCOMPANIED BY DETAILED INSTRUCTIONS FOR THE PRODUCTION OF CALCIUM CARBIDE AND OTHER DIRECTIONS AND WORKING NOTES.

By Nevil Monroe Hopkins.

It occurred to the writer in wiring up a couple of experimental arc lamps across the feeders of an incandescent lighting system, that a laboratory electric furnace could be operated on a series carbon plan, without disturbing the protecting fuses of the circuit. This idea of concentrating a pair of arcs within a small crucible or furnace, using only the amount of resistance wire located in the tops of the lamps, proved to be crude, the current taken being excessive upon introducing a charge for fusion, when its character embodied fair electrical conductivity. In order to obviate this difficulty, as well as to compensate for the lowering of resistance due to eddy currents between the carbons, a triple series arc was formed requiring only a short length of German silver wire to steady its action. With this arrangement the most successful results were attained, and with the furnace, as finally constructed upon this plan, many metallurgical processes were carried on, a 12 ampere fuse placed in each leg of the current supply being sufficient. The little furnace illustrated in Fig. 1 is capable of producing calcium carbide in twenty minutes from the time the current is switched on, the fuses remaining intact throughout the operation, if a short length of resistance wire is introduced into the circuit. With this arrangement it is possible to separate the carbon electrodes 3½ inches without extinguishing the triple arc. It is the intention of the writer to describe in detail the construction of this little plant, and furnish carefully prepared directions for making small quantities of calcium carbide. This compound is chosen because of its exceedingly useful and interesting characteristics, and because of the numerous inquiries the writer has received in regard to its formation on a small scale. Calcium carbide is a highly refractory body, its preparation requiring the highest temperatures, and its successful production by means of this small electrical equipment urges experimentation with other compounds requiring less energy and a lower temperature.

Fig. 2 will enable us to understand the mounting and connecting of the carbons, being a plan view of the system. The initial steps in putting together this little equipment should consist in forming and lining the furnace proper. The shell is made from sheet iron, cut to exactly incase one of the common sizes of fire clay slabs. The exact size and shape of this furnace is, of course, immaterial, provided the length is not over 13 inches from end to end, as shown in Fig. 3. Should the length exceed 13 inches, standard electric light carbons would not prove long enough to meet at the center. As the fire clay slabs adapted to our purpose vary somewhat in length, definite dimensions are not given, but those shown in Fig. 3 will be found useful as guides, and are approximately suited to the average sized slab sold for backing up fire places and stoves, which are plane on one side and fluted on the other. Having procured four of these slabs, the sheet iron (No. 18 or 20 gage) may be marked off carefully and bent to form the shell. The overlapping sides are drilled through and securely riveted together. One of the fire clay pieces is now placed in the shell on either side (the fluted surface next to the iron) and a large fire brick dropped in between them. These large fire bricks come with a recess in the top, as represented in Fig. 1, which is desirable for collecting small fusions. If the three pieces of fire clay fit nicely in the shell, the fire brick is removed temporarily, and our attention given to cutting one of the slabs in half to form the ends of the lining.



A SIMPLE LABORATORY FURNACE.

In Fig. 3 a section of the shell is shown, where *A* represents one of the side slabs in position, running from end to end, as illustrated by the horizontal shading. These slabs may be had about 12½ inches in length by about 8 inches in width and 2 inches thick, which serve for this lining nicely. The end pieces must be cut off at an angle to form the bottom of the incline leading into the furnace. These are represented in the drawing by section, in oblique lines. The fire clay is cut with a cold chisel and hammer, working slowly with uniform blows, exercising some little patience, until the pieces have the proper shape. The angle must be determined by trial with the shell, which is cut down by means of heavy shears, within 5 inches of the bottom, being about 5½ inches in width. The metal flap, resultant of this cutting down, is sharply bent over and cut off, the edge being smoothed with a large flat file. A band of iron riveted around the top, as illustrated, crowns the opening, and must be adjusted as to height, by the size and thickness of the fire clay lining which has been procured.

To complete the furnace proper, it is only necessary to put in place the angle pieces; and secure in position temporarily four pieces of glass, in order to form the top of the inclined entrance. The wooden brace, *B*, is cut to the proper length to press the vertical glasses (shown in simple ruling) against the end pieces of fire clay, and small wooden blocks made to support the glass plates on the incline, as illustrated, leaving a 2 inch space. The height of the vertical glass plates must be just equal to the height of the side slab, *A*, and the inclined pieces must come nicely in contact with them. The two spaces formed, *C* and *D*, are now filled in with "stove fix" or other fire clay compound made plastic by the addition of a little water. This compound may be had ready to mix, and is applied with a trowel. The glass plates must be left in position over night, in order that the material which they support may set. They are then withdrawn together with the wooden brace, and the fire brick dropped into the bottom to stay. An additional quantity of the stove compound is made up, and all cracks and crevices

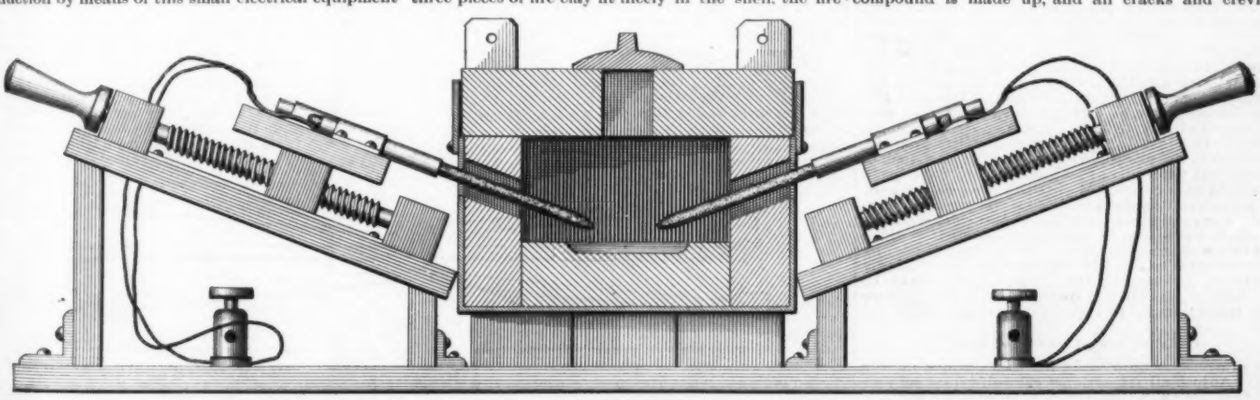


FIG. 1.—PARTIAL SECTION OF "SERIES CARBON" LABORATORY ELECTRIC FURNACE.

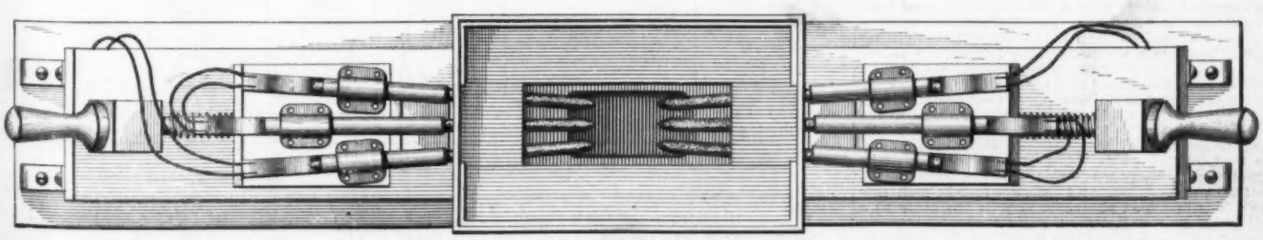


FIG. 2.—PLAN VIEW OF FURNACE, SHOWING CONNECTIONS.

plastered in. When this finally sets, a strong and durable furnace is produced. It should be heated up slowly for the first time uncovered, in order to expel all moisture. The top, which consists of the fourth piece of slab, is cut through by means of the cold chisel, and is afterward smoothed with a large rasp.

The method of suspending the cover is illustrated in Fig. 4, the iron bands coming over the fire clay walls, on the inside, being thus protected from the heat of the arcs. Having completed this portion of the work, the base, platforms, and screw feed must be put to-

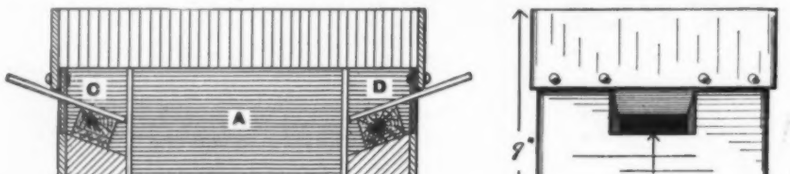


FIG. 3.—METHOD OF FORMING AND LINING FURNACE.

gether. The base, upon which the entire plant rests, consists of a heavy pine board, 4 feet in length by 8 inches in width. The furnace is mounted upon three common bricks (2¼ inches in height) and placed at the center of the board to facilitate the design and construction of the inclines, which must be very accurately pitched, in order that the carbons may be fed into the furnace without coming in contact with the openings. Should they touch, however, a couple of mica sheets must be applied as a precaution against short circuits. These inclines are made from 1 inch pine boards, 6 inches in width and 16 inches in length. These boards are mounted upon upright pieces of wood of the same weight for trial, but are not screwed on until the screw feed is put in place, which is attached from underneath. Of course the inclines must be carefully adjusted to any specific furnace, but the height of the front and back supports will be about 8 and 3¼ inches respectively. These may be attached at once by means of strong angle irons as illustrated in Fig. 1. To form the screw feed, select a large sized furniture maker's clamp, with wooden screws at least 18 inches long. Fig. 5 illustrates such a clamp, the sections to be sawn through to make the bearings and screw collars being marked in dotted lines. The sec-

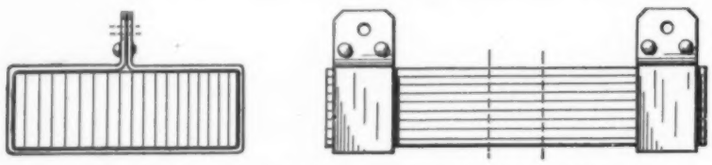


FIG. 4.—CONVENIENT METHOD OF HANDLING COVER.

tions marked *S S* will be found to contain the screw threads, and serve for the center traveling pieces upon which the blocks and electrodes are mounted. The sections 1, 2, 3, and 4 serve for simple bearings, after being carefully drilled through with a bit and brace, exercising great care in boring, to secure centrally located straight holes. These are screwed on to the board from underneath, and as the wood from which the furniture clamps are made is very hard, gimlet holes must be provided for the reception of the screws to prevent splitting. These gimlet holes must have considerable depth. Upon the traveling pieces are mounted two blocks 6 inches long, 4 inches wide, and about 1¼ inches in thickness. Three brass tubes are carefully mounted upon each of these, of the right size to receive electric light carbons (the longest kind, copper coated) with a tight fit. These tubes are secured as shown in Fig. 2 by means of heavy brass straps. The carbons are placed in position, about an inch of the end left protruding to allow brass spring clips to be pushed underneath. With this spring adjustment, the carbons can be quickly withdrawn or easily regulated. The connections, which should consist of double insulated wires (No. 16 gage), are soldered to these clips in the manner indicated. It will be observed by referring again to Fig. 1 that the carbons may be slowly withdrawn by turning the screw, or they may be pulled out of the furnace by the handle of the screw when it is necessary to remove the furnace from the base.

CONNECTIONS AND OPERATION.

The furnace is now ready for connecting up and a trial. Adjust all six carbons carefully, making sure that they are all in contact. When the triple arc once forms, they require very little attention, and, as stated, will continue to burn when the distance between their ends exceeds 3 inches, with a charge of coke and lime as the conducting medium. Fig. 6 shows the scheme of proper connections with a 110-volt electric lighting system. The main conductors, or feeders, are represented at the bottom by heavy horizontal lines and are joined as indicated direct to a porcelain fuse block, *F*. This connection should be made as near the meter as possible, in order to avoid annoyance from intermediate fuses. In addition to this, the capacity of the meter should be ascertained, which should allow of a 25 ampere load. In other words, a 45-light meter will be large enough, a standard 16 candle power lamp taking about 0·6 ampere. Place a 12-ampere fuse in each side of the fuse block, as shown, and join the same to a small knife switch, *S*. Should the reader possess an ammeter (of fully 50 amperes capacity), it should be included in the circuit, and a voltmeter should be joined across the connections of the arcs if possible. The resistance, *R*, consists of 20 feet of doubled German silver wire, No. 22 gage, Brown & Sharpe.*

To make this resistance in convenient shape, the wire should be wound about a large fire clay slab, which serves for sufficient insulation and resists the effect of the heating up. This slab with its wire must not be placed near woodwork. The furnace should be run for fifteen or twenty minutes, for the first time without its cover and without a charge, moving the carbons back and forth and testing their centering, but with considerable work, the lime and coke may be suitably prepared for fusion.

The powdered charge must be put away in airtight receptacles, if it is not intended for immediate use, as the lime in the finely powdered state quickly slakes if left in contact with the air. Should we use the mixture without thoroughly grinding, which is a very dark slate color, it will be found a very light gray upon shutting down the furnace after a run, showing that most of the carbon has gone off as carbon dioxide and carbon monoxide, leaving the unfused lime behind. We can now start the furnace for actual work and feed four or five ounces of the charge into the arc as soon as well started, observing the voltmeter and ammeter, if a study of the resistance of furnace fusions is to be made. The carbons are drawn gradually apart, and additional quantities of the charge added from time to time. The cover is kept on as much as possible, only removing it to add more material and to heap the compound about the triple arc by means of a spatula. After a twenty minutes' run, during which time the compound is frequently heaped about the points of the electrodes, the switch may be opened and the furnace allowed to cool. Should one of the fuses blow out during the run, it should be immediately replaced by one of the same capacity and a small amount of additional German silver wire added to the circuit, although the 20 feet of the double material will probably afford all the protection necessary and steady the arcs in a very satisfactory manner.

A variable rheostat of low resistance included in the circuit would be a great convenience, allowing the current flow to be adjusted to the capacity of the fuse wires to a nicety. A few runs with the furnace will enable one to become quite expert in forming calcium carbide, working with a 3-inch arc without allowing it to go out. When the furnace has cooled, a number of large masses of the carbide will be found in the bottom of the fire brick hearth, which may be thrown immediately upon water to obtain acetylene gas or stored away in airtight cans or jars for future use. If left open in the air, it is slowly attacked by moisture and is decomposed. Before suggesting other work for small preparations, the introduction of a very small crucible furnace may be of interest. Fig. 7 illustrates the simplest form of crucible equipment designed for operation on the 110-volt circuit, with six or eight 32 candle power lamps arranged in a bridge in multiple as indicated. A large sand crucible or ordinary flower pot is filled with granulated fire clay or other poor conductor of heat, and a smaller crucible placed in-

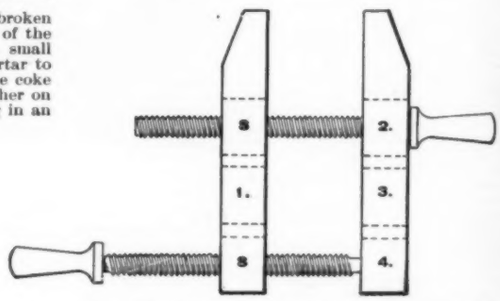


FIG. 5.—SECTIONS OF CLAMP AS APPLIED TO SCREW FEED.

side. The whole is stood on a fire brick and the large pot or crucible is provided with a clay cover having holes for the reception of two carbon electrodes. The stands sold for supports in chemical laboratories make the most convenient holders for the carbon rods.

The furnace depicted in Fig. 8 is capable of doing more work, in fact, as much as may be wished for on a small scale, if the experimenter is so situated that he may have as much current as he wants. The small crucible is drilled through the bottom, and one of the electric light carbons cemented in place, or simply held in position by a tight fit. The outer incasement in this design consists of a large flower pot, supported on a small iron ring stand, also to be had from chemical dealers. This is covered by a heavy plate of mica with a central hole for the carbon. By putting in series two or three rheostats the current may be easily controlled, and if heavy fuses are installed, and if there is no fear of injuring any meter, a very fierce and intense arc may

iron coffee mill. These mills come all of iron, designed to screw up against the wall, and are equipped with a regulating device for grinding coarse or fine. The money put in a mill of substantial character will be well invested, as it will prove of great value in a laboratory or experimental shop for reducing many substances to powder. The granulated lime and coke are poured into the mill and ground to the finest meal, passing the mixture through several times to insure an intimate mixing as well as a fine powder. Should a mill not be at hand, the charge may be reduced to the proper fineness, although requiring much more labor, by means of the large iron mortar. The pestle of the mortar is ground to the right and the mortar rotated to the left with the palm of the left hand. There is a little knack in doing this, and with a little practice,

* This wire requires much care in handling, and if allowed to tangle or kink, breaks very easily. It is very brittle.

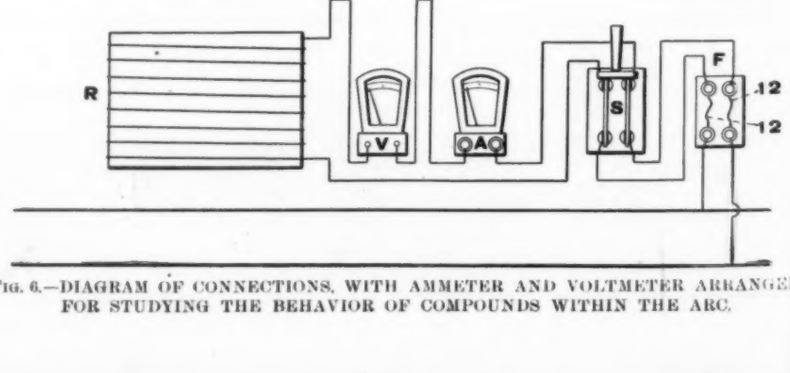


FIG. 6.—DIAGRAM OF CONNECTIONS, WITH AMMETER AND VOLTMETER ARRANGED FOR STUDYING THE BEHAVIOR OF COMPOUNDS WITHIN THE ARC.

be maintained. Use only the coppered carbons, and solder their connections to them. The writer suggests experimentation with alloys, in connection with these small crucibles (sand crucibles, plumbago, or graphite), using borax in some cases and charcoal in others (here the light floury charcoal is to be preferred), in order to fuse the bodies in a neutral atmosphere.

By using an excess of charcoal constantly in the crucible, the inert carbonic acid gas which is formed will expel the oxygen from the crucible and prevent oxidation of the metals experimented with. Nearly all the metallic oxides may be reduced in the presence of carbon with a sufficiently high temperature, providing an interesting field for work. Small masses of aluminum and aluminum bronze may be formed in the crucible furnace illustrated in Fig. 8, or in the large triple arc equipment, although only on a very small scale. Aluminum oxide (Al_2O_3) may be directly reduced in the arc in the presence of carbon by introducing an intimate mixture of the oxide and powdered graphite. The aluminum oxide may be bought, or may be prepared on a very small scale from clay or alum as follows: Digest 8 ounces of clay in a mixture of hydrochloric and sulphuric acids in a glass flask (HCl 3 parts, H_2SO_4 1 part) for about an hour. The fluid is mixed with four or five ounces of water and filtered. An excess of ammonia (ammonium hydroxide) is added, and the white precipitate collected on a large filter and allowed to dry. It is then mixed with the graphite and the two ground together. From alum, it is only necessary to add the ammonia to a strong solution of alum in water, and treat the resultant precipitate in a like manner. Of course this process is only a little chemical exercise, and is only given for the benefit of those who wish to attempt the entire process, although of no commercial value, the manufacture of aluminum embodying entirely unlike methods.

For the benefit of those who have never experimented with the electric arc, the writer includes in the suggestions offered a pair of strongly smoked glasses, to be worn whenever the arc is exposed. To work without glasses is to expose the eyes to severe strain and possible injury.

Laboratory of N. Monroe Hopkins.

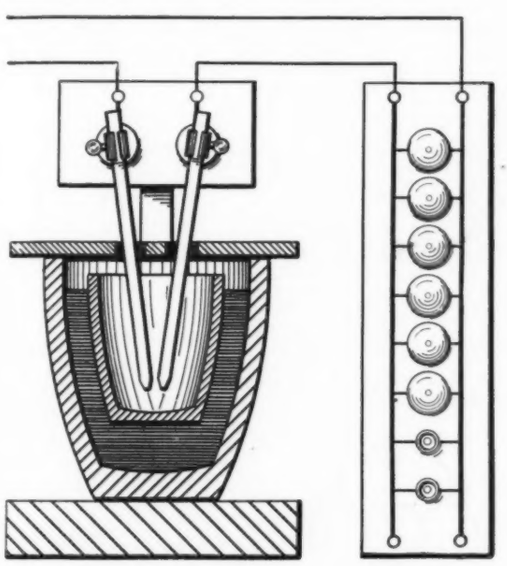


FIG. 7.—FURNACE FOR MAKING SOLDERS AND OTHER ALLOYS HAVING LOW MELTING POINTS.

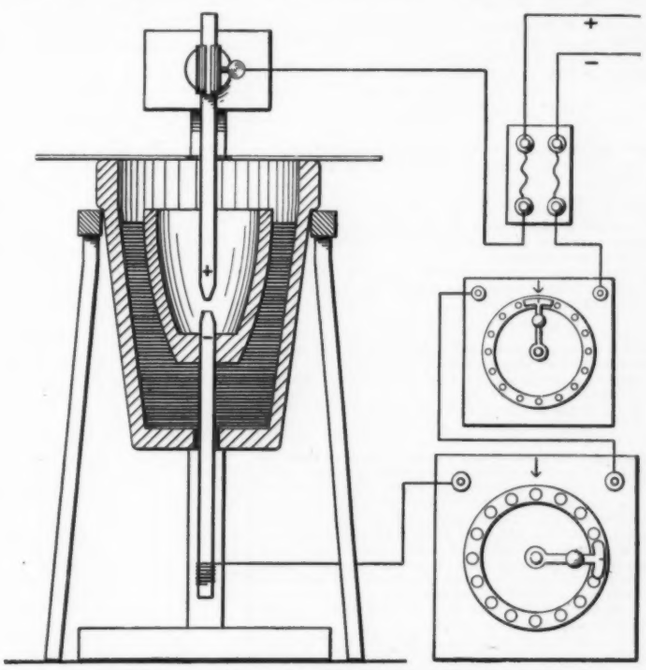


FIG. 8.—FURNACE FOR MELTING BRASS, COPPER, ETC., FOR HARDER ALLOYS, AND REDUCING SMALL QUANTITIES OF METALLIC OXIDES TO THEIR RESPECTIVE METALS.

OUR KNOWLEDGE OF THE VALUE OF A RESISTANCE.

By Prof. W. E. AYRTON, F.R.S.

THE ohm was the first of the absolute electrical units which it was attempted to realize in practice, and during the past thirty-five years at least twenty-eight distinct attempts have been made in America, England, France, Germany, and Italy to accomplish this end with greater and greater accuracy.* It is interesting, then, to consider with what degree of accuracy we can at the present time state the resistance of any particular conductor in absolute measure.

The Order in Council signed by Her Majesty in August, 1894, says, in reference to the electrical standards of the Board of Trade: "In the use of the above standards, the limits of accuracy obtainable are as follows:

"For the ohm, within one-hundredth of one per cent.

"For the ampere, within one-tenth part of one per cent.

"For the volt, within one-tenth part of one per cent."

The first of these provisions is equivalent to saying that the resistance of a conductor of about one ohm will be certified to one ten-thousandth part of the resistance of the "instrument marked Board of Trade Ohm Standard, Verified 1894." But it is not clear from the Order whether, if a coil of about 100,000 ohms were sent to the Board of Trade laboratory to be tested, its value would be certified to one ohm or only to ten ohms, since the latter is one-hundredth of one per cent. Still less does the Order tell as to what degree of accuracy the value of a one-hundredth or of a one-thousandth ohm coil could be given, since the limit of accuracy must, of necessity, be diminished the smaller the resistance of the coil to be tested.

Of one thing, however, my own experience makes me quite certain, and this is that any inquiry about the resistance of any coil, whether high or low, will be cordially responded to by Major Cardew, and the resources of the Board of Trade will be promptly utilized to enable the fullest information in his power to be given.

Small resistances to carry large currents are coming more and more into commercial demand, for one of the most ordinary methods of measuring large currents in practical use at the present day is to measure the P.D. between the terminals of a low resistance. So that a high-reading ammeter is very frequently a combination of a low-reading D'Arsonval voltmeter with a strip of low resistance, which may be inside the voltmeter case or may be a part of the actual electric light main in a central station.

Now if a current of say 5,000 amperes is to be measured—quite an ordinary current to-day; quite a small current an American street railway engineer would call it—a resistance of one-thousandth of an ohm would be unnecessarily high. For that would mean a drop of five volts in the pressure, whereas the voltmeter can easily be constructed to give its maximum deflection for a fraction of a volt. A ten-thousandth of an ohm, that is 100 microhms, would be quite large enough—would be too large, perhaps, some might even say—hence, the measurement of such a resistance to, at any rate, one per cent., that is, to one microhm, will soon be regarded as merely a piece of rough workshop measurement.

Those who have been accustomed only to think of standard resistance coils as top-heavy brass boxes, with long metal legs dipping into mercury cups, will, on reading the preceding, immediately feel anxiety about the resistance of the contacts in the mercury cups. Surely a variation of much more than a millionth of an ohm at the terminals will be likely to occur. But the one ten-thousandth ohm of the electrical engineer does not mean a coil which, when attached in a somewhat uncertain way to the terminals of a Wheatstone's bridge, will indicate a resistance of 100 microhms with an accuracy of 1, or some specified fraction of a microhm, but it means some form of strip which, if constructed to carry 5,000 amperes, is such that a P.D. of half a volt will be set up between two definite points in it when a current of 5,000 amperes is flowing along definite stream lines; these stream lines being determined by the current being led into and out of the strip through specially constructed massive copper ends.

As far as our knowledge of the values of the units is concerned, such a resistance can be tested in absolute measure by means of electrolysis in combination with a Clark cell, not merely to one part in a hundred, but to one part in a thousand. Neither the electrochemical equivalent of silver nor the E.M.F. of any Clark cell, it is true, are known in absolute measure to 0·1 per cent., seeing that there is good reason for believing their reputed values of 1·118 milligrammes of silver per second per ampere and of 1·434 volts at 15° C. are each about two parts in a thousand too small. But the latter value is based on the former and on our much more accurate knowledge of the value of the ohm, hence—as far as our knowledge of units is concerned—we can ascertain the value of a resistance by means of electrolysis and a Clark's cell to a greater degree of accuracy than we know the electrochemical equivalent of silver, on which our current measurement is based, or the E.M.F. of the Clark cell used in the measurement of the P.D.

But the practical difficulty connected with such a determination of a very small resistance is quite another matter. Either the current used must be large or the P.D. must be small, and each known accurately to 1 or 0·1 per cent., as the case may be, in terms of the international units of current and P.D. respectively. If the resistance be about 100 microhms, and one per cent. accuracy will suffice, and if we have a potentiometer arrangement which will divide the one hundredth of the E.M.F. of a Clark cell into 100 exactly equal parts, it will be only necessary to electrolytically measure a current of about 100 amperes accurately to one per cent.

But if, on the other hand, this same resistance of about 100 microhms is to be tested with an accuracy of one part in a thousand, then with the same subdivision of the E.M.F. of the Clark cell just referred to, we shall have to electrolytically measure a current of about 1,000 amperes correct to one ampere. This, however, would be attended with many practical difficulties, and therefore it would be better to measure the value of some smaller current electrolytically, and then to determine the value of the larger current by some method giving their relative values.

The direct comparison of a low resistance strip with the Board of Trade ohm standard remains to be considered. If the resistance to be measured were a tenth ohm or a hundredth-ohm this could, of course, be done, but if it were of the order of one ten-thousandth of an ohm, that is 100 microhms, furnished with potential wires, and if it were made of a short piece of thick metal, so as to carry a current of some thousands of amperes without heating, such a direct comparison would be extremely difficult, if not impossible, to be carried out, even when an accuracy of only one per cent. was aimed at. An indirect comparison, in which intermediate resistances were employed as steps in the process, would be feasible but lengthy.

On the other hand, with a properly constructed Lorenz apparatus the value of such a 100-microhm strip could be ascertained in absolute measure easily to 0·1 per cent. and with sufficient care to probably two or three parts in ten thousand. In other words, when the centering, etc., of the Lorenz apparatus has been once effected, and the calculation of the coefficient of mutual induction has been once carried out, not only can a very small resistance be measured far more easily with a Lorenz apparatus than by direct comparison with a standard ohm, but, if desired, the result can be obtained in absolute measure to a greater degree of accuracy than that with which the value of the standard ohm will probably be known.

Further, although the probability of variation with time in the resistance of such a coil as the standard of the Board of Trade is small, no molecular change affecting the specific resistance either of the phosphor-bronze of the disk or the copper of the field-coil winding would affect the accuracy of a resistance measurement made with the Lorenz apparatus.

It may, however, be urged against the Lorenz apparatus that only a small resistance can be measured by means of it. This no doubt on the face of it is true, and it may be added that in the recent determination of the ohm at the Central Technical College, the resistance which was measured had a value of about one two-thousandth of an ohm, or 500 microhms. For this the disk had to be rotated at about 600 revolutions a minute, but it could have been run quite safely at double or treble this speed, so that the value of a resistance of about one-thousandth or one seven-hundredth of an ohm might equally well have been measured.

But that is still very small the advocates of coil standards will reply. Yes; but by the employment of the method described by Lord Rayleigh* and used by Prof. Viriamu Jones in his Cardiff determination, as well as in our recent joint determination of the ohm, this resistance of one seven-hundredth of an ohm can be formed, for example, of two one-ohm coils and two 349-ohm coils, each of which, of course, can be compared very accurately with the Board of Trade ohm standard in the ordinary way.

The argument, therefore, which has been advanced

* For the history of these determinations, see "Practical Electricity," edition of 1896, Appendix III., pp. 502-600.

* Phil. Trans., 1888, A, p. 342.

from time to time by Prof. Jones that the ultimate standard of resistance of a country should be defined as the most accurate result that can be obtained with a well-constructed Lorenz apparatus in the possession of the government is obtaining greater and greater weight. For when once it has been shown that a Lorenz apparatus is capable of giving results of sufficient accuracy, there remains no more reason for defining the government ohm as the resistance of some particular piece of material than for defining the true ohm in a like way.

As at present, an actual coil would doubtless be the everyday working standard; indeed, it would probably be convenient to have a set of secondary resistance standards of various values. But instead of the Board of Trade ohm being legalized as the resistance of this particular coil, and its being left to outsiders to find out how many true ohms are contained in the Westminster coil, the government would take possession of the true ohm in the form of the Lorenz apparatus, and their officials would from time to time ascertain with greater and greater accuracy the value in true ohms of the resistances of their various secondary standards.

With what degree of accuracy to-day can the resistance of a conductor be stated in absolute measure was the starting point of this article, and the answer to that question shall be the finish. We must, of course, carefully distinguish between the accuracy with which a multiple of the Board of Trade ohm can be produced and what we know of its absolute value. Experiment may show that the resistance of a particular coil is exactly 100,000 times that of the Board of Trade ohm, but for aught we know to the contrary, even now at the end of 1897, the value of this coil in true ohms may be 100,020 or 99,980, for the following is the result of the last three absolute determinations:

1891.—Cardiff determination of the specific resistance of mercury in absolute measure. Result, after correcting for the ellipticity of the coil:

Specific resistance of mercury at

$$0^\circ \text{ C.} = 94074 \frac{(\text{centimeter})^2}{\text{second}}$$

Hence, expressing the true ohm in terms of the resistance of a column of mercury 1 sq. mm. cross section at 0° C.,

One true ohm = 106·300 cm.

1894.—Cardiff absolute determination of coils which had been tested by Mr. Glazebrook. Result, after correcting for the ellipticity:

One Cambridge ohm = 0·99983 true ohm. Hence, if the Cambridge ohm be really the resistance of 106·30 cm. of mercury,

One true ohm = 106·32 cm.

1897.—London absolute determination of coils which had been tested by Major Cardew. Result:

One Board of Trade ohm = 1·00026 true ohms. Hence, if the Board of Trade ohm be really the resistance of 106·30 cm. of mercury,

One true ohm = 106·27 true ohms.

At the present time, then, we can only say that the resistance of any particular conductor, or the specific resistance of any particular specimen of material, lies between limiting absolute values differing from one another by as much, perhaps, as four parts in ten thousand. But we can add that we are certain that these limits could be brought much closer together if secondary standards in the government laboratory were frequently brought into comparison with a Lorenz apparatus which had been constructed with all the resources and skill now at the command of the mechanical engineer.—The Electrician.

AN AMERICAN SMOKELESS POWDER.

By FREDERICK H. MCGAHIE.

THE admirable ARMY AND COAST DEFENCE SUPPLEMENT OF THE SCIENTIFIC AMERICAN contains in the article upon smokeless powders this sentence: "It is sincerely to be hoped that every effort will be made to substitute it altogether for the obsolete brown powder with which we are handicapped in the present war."

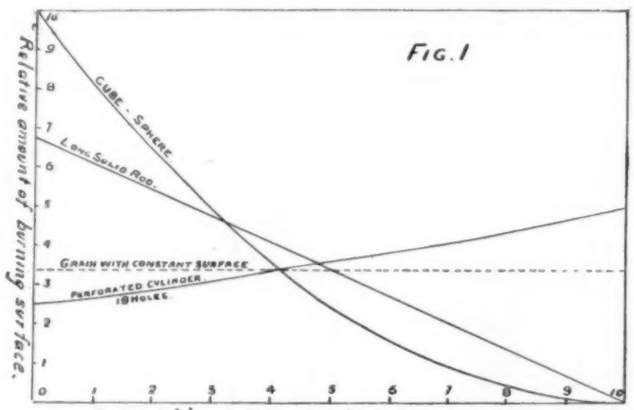
The virtues of smokeless powder that have caused it to supersede brown powder are absence of smoke, increase of projectile velocities and energies, reduction in weight of charge, and greater regularity of action. Smokelessness means inability of attacking or defending forces to locate satisfactorily on land opposing guns or concealed troops, and in naval operations no interference with gun fire; increased velocities give flatter projectile trajectories, with consequent improved accuracy of fire; increased projectile energies correspond to greater penetrative power; reduced weight of charge allows the carrying of a larger number of rounds of ammunition and permits the securing of the higher velocities without endangering the present gun mounts; greater regularity of action gives better chances of successful hits. Hitherto the chief drawback of the smokeless powders has been the accompaniment of high ballistics by excessive erosion. Bad chemical and mechanical stability is due to ignorance of the subject, as was exemplified in the case of the inventor of a powder, much exploited in the past, who stated in a patent specification that dinitrobenzene and urea were chemical equivalents.

The basic constituent of these powders is nitrocellulose, of which there are many varieties, differing in their explosive power and chemical properties. They are broadly divided into soluble or low grade guncottons and insoluble or high grade guncottons with reference to their action with a mixture of ethylic alcohol and ethylic ether. They are more exactly specified by the percentage of nitrogen they contain. Guncotton cannot be used in its original condition in guns, for it burns too rapidly, however much it may be compressed. But, when dissolved in a solvent and the solvent dried out, a dense colloid results, with a much slower rate of combustion that is controllable for the various conditions of gunnery, through its property of burning on the exposed surface only. Thus a cube remains a cube in all stages of combustion.

By means of a common solvent, nitroglycerine may be incorporated in various proportions with nitrocellulose. Early experiments with such powders developed the facts that, while the nitrocellulose type gave reasonable erosion, the desired increase of ballistics in high power guns could not be secured, and that the nitroglycerine type gave ballistic and erosive effects corresponding to the percentage of nitroglycerine used. How serious this wear upon the gun is in such cases may be gathered from the following comment from the 1895 Report of the Chief of Ordnance, U. S. Army, upon tests of a high grade nitroglycerine powder: "The results with this powder were particularly favorable as regards velocity and pressure. The indications, however, of extreme heat were very apparent; the mushroom head showed plain signs of erosion and the manufacturers' marks on the pressure gages were completely obliterated in a few rounds." Improved armor makes heavy demands upon the high power rifle, and the question of compromising between these antagonistic properties of smokeless powder has been a perplexing one. With the nitroglycerine type the tendency has been to add some inert substance or weak nitro compound to lower the temperature of explosion, the preponderating cause of erosion. The effect is limited. Sometimes nitrate of barium is added to the nitrocellulose type to increase its ballistic power, but this plan has the disadvantage of a corresponding amount of smoke by the formation during explosion of a solid compound, barium carbonate. The true smokeless powders yield entirely in decomposition under service conditions colorless gases. In the case of black powder the smoke-producing solids constitute 56 per cent. of the products of combustion. Typical powders are cordite, with 57 per cent. nitroglycerine, 38 per cent. high grade guncotton, 5 per cent. vaseline; ballistite, with 50 per cent. nitroglycerine and 50 per cent. soluble guncotton; B. N., with 60 per cent. mixed guncottons, 20 per cent. barium nitrate, 10 per cent. potassium and sodium nitrates, the solvent employed attacking the soluble guncotton only; Peyton powder, with 40 per cent. nitroglycerine, 40 per cent. soluble guncotton, 20 per cent. picrate of ammonium.

An American powder, the Maxim-Schupphaus, offers a superior and scientific solution of the problem whose correctness has been proved by trials and tests extending over the last four years. It is the standard of the United States army, and, after futile attempts to produce a satisfactory powder of their own, the United States navy has lately adopted it.

Robert C. Schupphaus, Ph.D., and Hudson Maxim were both pioneers in the American field, having submitted independently in 1890 smokeless powders for the small caliber rifle upon which the ordnance department of the army had begun experiments. Excellent results were secured, but no prospect of any business for years led them to abandon their work. These powders embrace the best types of present small arms powders. In 1893 they combined to develop a system of projecting large masses of high explosives from rifled guns. The first need was a propellant that would give a less sudden initial acceleration of the projectile, with a subsequently more uniformly sustained acceleration than was possible with known powders. At the same time the production of a suitable powder for the large rifles was kept in mind. The philosophy of the solution was the use of guncotton as the chief constituent to insure low erosive effects and the employment of a form of grain such that the surface exposed to the igniting flame would be relatively low and then increase rapidly up to the moment of complete combustion. The result would be that the projectile would be started gradually and then followed in its movement by such a rapidly growing amount of gas that the accelerating pressure on its base would be well sustained and tend to the limit of following the curve of tangential elastic resistances of the gun. Recalling the property of colloidal, smokeless powders of burning up geometrically layer by layer, let us examine the influence of the form of grain. The long solid cylinder represents the best average conditions. Its burning surface is a maximum at the moment of ignition and decreases rapidly to zero as the square of the diameter at any instant during combustion. The point involved is better illustrated by considering that, when the rod is burned half way through, the amount of its weight transformed into gas is ¾. Now this occurs when the shell has traveled approximately ⅛ of its distance along the bore, and there is left but ¼ of the charge to pass into powder gas during the remaining ⅞ of the shell's travel. This is evidently not an ideal way of sustaining the pressure. Theoretically a rod pierced with a central hole and a laminated grain of such dimensions that the end surfaces are negligible are better, both giving a constant burning surface. But in practice laminæ give very irregular results, the packed grains hindering free inflammation, and the pierced rod has to be in such short lengths to avoid disruption by accumulated powder gas in the hole that the end surfaces enter appreciably into the case. In the development of the Maxim-Schupphaus powder it was calculated that by the use of a cylinder perforated with many axial holes the initial surface would be less than with any other practical grain, and that the burning surface and rate of emission of gases would be increasing functions. Fig. 1 shows this graphically. It is based upon the assumption that equal charges of any formula are made up into the shapes indicated, the burning thickness of the grains being the same. The details of shaping dies being settled, the real difficulty obtruded itself in the shape of a working formula of the nitrocellulose type. Experiments with powders based upon all the knowledge of the day failed to give satisfactory results. Two conditions prevailed. Either the rod upon leaving the die would swell irregularly with a corresponding distortion and closing up of the perforations, or, if the rod was perfectly shaped, it would soon warp to pieces. Powder grains must be uniformly exact and mechanically strong. Extensive experimenting led to the discovery of a new property



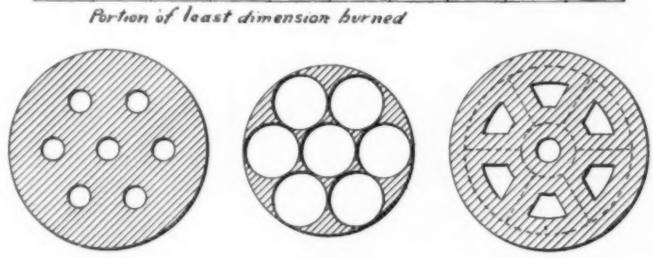


FIG. 2. FIG 3. FIG 4.

THE MAXIM SCHUPPHAUS MULTI-PERFORATED SMOKELESS POWDER.

of nitrocellulose, a combination of guncottons that when treated with a solvent in the usual manner gave an inelastic compound taking all complicated dies in the most elegant manner, free from warping strains in drying, and plastic under heat. It permitted the admixture of nitroglycerine and solid compounds in all permissible amounts. Tests were made in the complete range of army guns, and the powder's high ballistic properties, excellent mechanical and chemical stability, low erosive effects, and unequaled regularity were fully demonstrated.

The commanding officer of Sandy Hook proving ground, in his 1896 report, wrote of its results, "They compare favorably with the best results obtained with foreign powders." Examination of the guns after firing showed always so little signs of erosive action as to excite comment by the officers in charge. Tests were made with various compositions in the small caliber rifle to ascertain their relative erosive effects. After 5,000 rounds the high grade nitroglycerine powder had caused a falling off in velocity of 150 foot seconds; the M.S. had caused none. The barrels were then cut open and examined. As the report stated, the erosion produced by the M.S. powder was quite slight and that by the high grade nitroglycerine very heavy. These firings gave also an excellent illustration of how the form of grain affects the ballistics of a formula. The small caliber rifle, with the necessity of a powder acting satisfactorily in the loading machine, permits only the very simple grains; so that results must be obtained through the formula entirely. The nitroglycerine powder in this rifle gave 2,000 foot seconds on 32,000 pounds pressure; the M.S. formula gave the velocity on 45,000 pounds pressure. Yet in the 3·2-inch field gun, permitting the multiperforated grain, the results were practically identical for the two powders. Some of the tests it has been through will indicate its satisfactoriness. A batch of powder was divided after acceptance tests into two lots, one being put into open boxes and the other being loaded up into fixed ammunition. After exposure for 18 months in a magazine to atmo-

spheric conditions the two lots gave results identical with the proof firings. It has been submerged under water for 15 hours and then dried in the open air without showing any physical changes or loss of power. After standing two or three years, no samples exhibited any reduction of chemical stability. The formula employed during its development was 90 parts mixed guncottons, 10 parts nitroglycerine, 1 part urea, the nitroglycerine being added principally to insure good ignition. But the M.S. powder is not a definite one. The formula can be varied widely, so as to meet all beliefs of ordnance experts. To illustrate this range, it may be said that the following powders have been most successfully manufactured into multiperforated grains under this system: pure guncotton powders with considerable variation of explosive power; powders with guncotton as the base containing from 5 per cent. to 60 per cent. nitroglycerine, alone or combined with desirable proportions of cooling compounds, such as picrate of ammonium, dinitrobenzine; guncotton powders with 10 per cent. to 40 per cent. of nitrate of barium. The army will use a powder containing about 25 per cent. of nitroglycerine, with a corresponding lowering of strength of the guncottons to keep the temperature of explosion down to that of the original formula. The navy will employ the nitrate of barium type. The American patents have been acquired by the famous firm of E. I. Dupont de Nemours & Company. Some firing records are given in the following table:

Gun.	Charge.	Projectile.	Muzzle Velocity.	Pressure.	Remarks.
8-inch steel rifle, U. S. A.	78 lb.	300 lb.	2,375 foot seconds.	34,200 lb.	125 lb. of brown powder gives 2,000 foot seconds on 37,000 lb.
10-inch steel rifle, U. S. A.	128 "	575 "	2,225 " "	34,500 "	250 lb. of brown powder gives 2,000 foot seconds on 37,000 lb.
12-inch steel rifle, U. S. A.	220 "	1,000 "	2,214 " "	36,000 "	450 lb. of brown powder gives 2,000 foot seconds on 38,000 lb.
5-inch siege gun, U. S. A.	5 "	45 "	1,830 " "	21,800 "	13 lb. of black moulded powder gives 1,830 feet on 35,000 lb.
	9·3 "	45 "	2,400 " "	35,000 "	
5-inch R. F. gun, U. S. N.	11·75 "	50 "	2,558 " "	34,000 "	30 lb. of brown powder gives 2,250 foot seconds on 33,600 lb.
47-inch Armstrong R. F. gun	6·8 "	55 "	2,085 " "	33,600 "	5 lb. 10 oz. of cordite supplied with gun gave 2,078 feet velocity on 29,500 lb. pressure.
47-inch Hotchkiss R. F. gun	10·9 "	35 "	2,913 " "	35,000 "	17 lb. of brown powder to give 2,280 foot seconds to 35 lb. shell and 1,700 foot seconds to 55 lb. shell.
	9·1 "	55 "	2,206 " "	33,300 "	
6-pounder R. F. gun, Driggs-Schroeder	1·25 "	6 "	2,370 " "	34,500 "	3 lb. of black powder gives 1,900 foot seconds on 35,000 lb.
7-inch howitzer, U. S. A.	4·75 "	105 "	1,105 " "	15,000 "	10·5 lb. of black moulded powder gives 1,100 feet on 38,000 lb. pressure.

Testimony to the value of the system can be found in the late reports of the Chief of Ordnance, U. S. A. I abstract the following: "An example showing the effect of form of grain occurred in my experience during the year. Working with a fixed composition, I endeavored, by varying the thickness of a flat grain, about three-eighths of an inch square, to adapt it to the field gun. The best results obtainable were 32,000 pounds pressure for the standard velocity of 1,450 feet per second. I then had the same material made in the form of a seven-perforated cylindrical grain and got at the first trial 1,450 feet per second with 26,500 pounds pressure. . . . All things considered, the perforated cylinder or disk proposed by General Rodman many years ago and recently revived in the Maxim-Schupphaus powder appears to me the most suitable and promising form for the colloidal smokeless powders."—Captain Sidney E. Stuart, Inspector of Powder.

"Experiments have shown that the most satisfactory form of grain, as being the most progressive, is the multiperforated cylinder, and as, by increasing the number of perforations, a grain of any desired size may be obtained for any given thickness of the walls between the perforations, it would seem that by this method a free and unhindered inflammation of the charge could be obtained and at the same time the maximum of ballistic power realized for a given type of powder."—Brigadier-General D. W. Flagler, Chief of Ordnance.

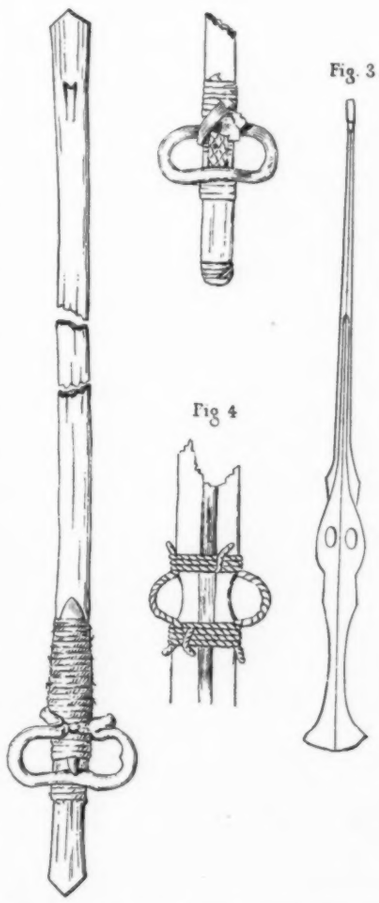
These records have been obtained with a form of grain not utilizing the system to its best advantage, so that higher ballistics are obtainable if desirable. Fig. 2 shows the section of the grain employed. With this grain the highest results are obtainable when it is proportioned to burn out to Fig. 3 as the projectile leaves the muzzle. But the unburned segments represent wasted powder and the very objectionable feature of flames from the breech in rapid-fire work. Consequently, a smaller grain, giving less favorable results, must be employed to secure this necessary complete combustion. The table refers to satisfactory grains. To obviate this a grain of section in Fig. 4 is now employed, the dotted lines indicating how complete combustion and maximum surface are correlated. An increase in the number of perforations will act advantageously. For use in torpedo guns the multiperforated grains will be coated on the outside with some very slow-burning varnish, so as to make the conditions yet more favorable.

A brief sketch of the manufacturing process will be undoubtedly of interest. The dry guncotton in the form of a fine dust is dumped into water-jacketed mixing machine with a helical frame blade with fair clearance. The liquid mixture of nitroglycerine and solvent is sprinkled slowly upon the guncotton while the blade is tumbling it about. At this point these explosive substances lose much of their sensitiveness and the ability of detonating. They can simply burn. The solvent makes this change. The cover being closed and warm water circulated through the jacket, mixing goes on for several hours. The resulting pasty mass is taken out and worked upon steel rolls to a firm sheet about one-quarter of an inch thick. The sheet is rolled up and put into a hydraulic stuffing press and the working head bolted on. This head carries a hole into which the dies may be screwed and also a valve connection from a vacuum pump. The die hole being closed with a blank plug, a vacuum is produced in the press, the valve closed, and the powder sheet compressed into a solid mass. The die is put in and the powder forced through it at a pressure of from 2,000 to 4,000 pounds per square inch. The issuing rod is cut up into suitable lengths, which are taken to the cutting machine to be chopped up into grains of the desired length. These are then put on racks in a room heated to 120° F. and dried to a constant weight. This takes from five days to fourteen days, varying with the size of the grain and the formula employed. A slight treatment in a vacuum drier then follows as a precautionary measure, and the powder is ready for shipment to the proving ground.

THROWING STICKS.*

PROF. O. T. MASON says: In Science (published in New York, September 15, 1893) I describe a throwing stick and a fragment which I discovered in the Colorado State Exhibit, in the Anthropological Building at the World's Columbian Exposition. You will find inclosed a drawing of this stick and of the fragment (Figs. 1 and 2), both from the cliff dwellings of Southwestern Colorado. It is described in Science in the following language: "The shaft is a segment of a sapling of hazel wood 25 inches long. At the distant end is a shallow gutter and a hook to receive the end of a spear shaft. At the proximal end or grip, in the more perfect specimen, about four inches from the extremity, is a loop on either side of the shaft; one for the thumb, the other for the forefinger; the remaining three fingers would be free to manipulate the spear shaft. These finger loops were made by slitting a bit of rawhide, sliding it down the proper distance on the stick, and forming loops less than an inch in diameter by bending the projecting ends of the rawhide and seizing them fast to the shaft. Just below these finger loops or supports are a long chalcedony knife or arrow blade, the tooth of a mountain lion, and a concretion of hematite seized by a plentiful wrapping of yucca cord." The fragment is the handle or grip of another throwing stick of nearly the same character.

Two years ago Mr. Frank Hamilton Cushing spent



his winter in San Marco, Florida, making excavations in a most remarkable series of pile dwellings and key dwellings. His discoveries are described in the "Proceedings of the American Philosophical Society of Philadelphia," for 1897. Among the wonderful objects which Mr. Cushing found were two throwing sticks. In each of them the hole for the finger was from ⅛ to ¼ of the length of the shaft distant from the inner or manual end. One of these specimens has the finger hole bored through the middle of the shaft, as in some Alaskan specimens, but in the other there are two finger holes cut through the wood of the shaft, which is widened at that point for this purpose (Fig. 3). These double finger holes put this Florida specimen in the same category with the Vancouver and Patzcuaro examples. These objects open up two new areas for the throwing stick, Southern Florida and Southeastern Colorado. Especial attention is here drawn to the Colorado examples in comparison with Doctor Seler's throwing stick from Coahuila, Mexico, here reproduced from page 230, vol. x., of this Archiv (Fig. 4). The finger holds are effected by means of loops of some textile material, the ends of which are seized fast after the manner of the rawhide loops in the perfect Colorado specimen.

It is interesting to note in the last named that the arrow head, the tooth, and the concretion wrapped on the shaft of the throwing stick give to it a ceremonial value. It was found in a grave in one of the cliff dwellings, and similar treatment will be seen in the case of Mr. Cushing's Zuni fetishes which are described in the Second Annual Report of the Bureau of Ethnology.

* "Internationale Archiv fur Ethnographie," Bd. xi., 1898.

LIBRARY SCHOOLS.

THE origin, rise, and development of library schools in America mark what in the future will be deemed an important epoch in the history of bibliography. These schools have opened the door of another profession to men and women alike, and promise to work a material change in the management of libraries in this and other countries. This change must militate to the general good of the reading public. It is an acknowledged argument that 10,000 volumes, administered, catalogued, and used in the best way yield more benefit and are of more value than 30,000 handled in an unintelligent and ineffectual manner. The object of such schools is to fit students for the delicate task of extracting from the volumes under their care the greatest amount of information and pleasure in behalf of the public, and of lending accurate aid to students and researchers who otherwise would often be at sea in their investigations.

The different steps in the evolution of the librarian and his functions are interesting. Originally he was a savant, a collector and preserver of precious manuscripts. Next he degenerated into a mere caretaker or jealous guardian. To-day the great librarians of the world are primarily learned men and students of book history. In America, however, there is a growing tendency to regard them as public educators and to demand in them technical knowledge and executive business ability, as well as general literary culture. In short, the future librarian is not to be merely a widely informed dilettante: he must be a professional worker. He will no longer pride himself on having kept a volume clean and uninjured for ten years or so, but will grow to regard his well worn editions with satisfaction and to feel positively pleased each time a book goes to the rebinder.

The library school established January 5, 1887, by Melvil Dewey, formerly chief librarian of Columbia College, in connection with that institution, was the first step taken in the direction of library reform in America or elsewhere. Its object was and still is to offer the aspirant for library honors the same advantages granted the lawyer, minister, or doctor in his chosen profession. The course of training is intended to give the pupil an insight into the methods of management and systems of classification used by all the large libraries of the world, the result of the work of the institution has been to inspire the public with greater respect for the calling of librarian, and those interested in it believe that the time will soon come when directors of libraries would no sooner consider taking inexperienced persons for librarians or assistants than they would think of trusting a case in equity to a man who had never studied law.

In the United States alone there are over 5,000 libraries of one kind or another. Allowing an average of three expert workers to each of these, which is a conservative estimate, we have 15,000 persons engaged in library work. The rank and file of these need constant recruiting, and new libraries are being formed from time to time, which call for trained library workers. It is this demand that the New York Library School is supplying. A corps of beginners cannot be taken into a library except with great loss to the institution. Their labor for many months is practically worthless. They occupy the valuable time and attention of the more experienced members of the staff, and the result is too often confusion. A student, however, who has taken a degree from a library school, would be competent to enter immediately upon his duties; to superintend the furnishing, lighting, and ventilating of the building; to purchase and catalogue the books; to furnish syllabi of reading on any given subject; to make the most advantageous contracts for the binding of periodicals and pamphlets, and to start and keep the institution in practical running order, at the least expense and in the shortest possible time.

The New York State Library School was the first, and is still the most important, institution of its kind in the world. During the ten years since its establishment numerous schools and training classes have been founded in other cities in imitation of it, most of which are presided over by its graduates. The most important of these are the Pratt Institute School of Library Training in Brooklyn, the Drexel Institute Library Class in Philadelphia, the State Library School of the University of Illinois in Chicago, the Maine State College Course at Orono, and the Los Angeles Public Library Training Class.

For the first two years of its existence the library school was operated in connection with Columbia College, but on the appointment of Melvil Dewey, its founder and director, to the position of secretary of the University of the State of New York, with headquarters at Albany, it was transferred to the regents' department, with quarters at the great granite Capitol, where it has since remained—the only direct teaching done by the University of the State of New York. At present the school is located on the fifth floor of the monumental Capitol building. Its general class room is a long, light chamber, with ten tall, broad windows overlooking to one side the residence portion

of the city of Albany as it stretches away northward, on the other the business quarter, with the Hudson winding through, and beyond everything the blue Catskills. Here the twenty-seven regular students at present in the school have their desks, each of which is furnished with every improved convenience, including an electric drop light for late work. The wall bookcases are filled with bibliographies, books of reference, samples of binding, records of classification, and the various aids which the efficient librarian has always at hand, but of which the average reader of books does not always understand the use or value.

Mrs. Salome Cutter Fairchild, B.L.S., is the vice directress of the school, and is ably assisted by Miss Florence Woodworth. The institution, like law and medical schools, offers only technical training. To enter it the applicant must be twenty years of age, and must pass satisfactorily a severe examination, including Latin, French, and German; literature, history, and general subjects. College-bred students are preferred, on the ground that their training has given them a wider culture, a broader view, and more general information, all of which are valuable in library work. The course covers two terms—junior and senior—each of which extends through a scholastic year. It costs residents of New York State $80 and non-residents $100, the payment of which is distributed through the two terms. This sum is merely nominal, but a certain number of hours' duty in connection with the State Library is required of each student. This is regarded by the State as equivalent to money, and at the same time affords the student experiences that are invaluable. In this way the training of the pupil is made practical, as well as theoretical. The junior year is devoted to elementary studies, such as cataloguing, elemental bibliography, shelf-department work, loan system, and bookbinding. The senior year covers a broader field, and includes lectures on the founding, government, and regulation of libraries; on library buildings of the past, present, and future; on library bookkeeping, library museums, and library history.

Although the decimal system of library numbering invented by Melvil Dewey is in general use in the school and in the State library in connection with the card catalogue system, all methods have a fair and careful hearing and explanation, so that the student entering any well regulated library will feel at home there. Both theoretical and technical breadth is aimed at, so that the pupil on entering his actual career can select for his own use the method he finds most convenient. In connection with the school is a museum of library appliances, which is the most complete of its kind in the world. Opening off from the general class room is the lecture room. Here two junior and one or more senior lectures are given every day. The regular lecturers and their general subjects are Melvil Dewey, M.A., Library Economy; Mrs. Salome Cutter Fairchild, B.L.S., cataloguing, loan system, and reading; Walter Stanley Briscoe, M.A., bibliography, classification, and history of libraries; Ada Alice Jones, advanced cataloguing; Dunkin Van Rensselaer Johnson, M.A., reference work and binding; Edith Davenport Fuller, dictionary cataloguing; William Reed Eastman, M.A., B.L.S., library buildings; and Martha Thorne Wheeler, indexing. Besides these, distinguished librarians from all over this country and elsewhere address the class from time to time.

Three degrees are conferred by the school—B.L.S., M.L.S., and D.L.S. (for Bachelor, Master, and Doctor of Library Science). The latter is granted only for conspicuous professional merit or distinguished service to librarianship, and only on the unanimous vote of the regents.

Up to the present the demand for library school graduates has far exceeded the supply. Over 225 pupils have been graduated from the New York school alone. Of these all who have desired positions have secured them, and consequently there are over 200 students of this institution scattered from San Francisco to Birmingham, England, all of whom are working to facilitate and improve library methods.

A noteworthy fact in connection with the personnel of the students is that three-fourths of them are women. This is not surprising, when it is considered that the work is peculiarly adapted to them, and as the salaries paid to librarians range from $200 to $1,500 a year—rarely over the latter except in distinguished cases—there is little inducement for men to enter the field. On the other hand, the average salary of librarians is above the average paid to women as teachers or in other lines of work. College-bred women are, moreover, peculiarly adapted by taste and talent to the handling of books, and the same qualities which make them good housekeepers help them to keep a library—which should be and generally is the most comfortable of places—in proper condition.

Another feature of the library school which deserves special mention is that any experienced library worker, whether college bred or not, is admitted to the institution for a partial course and can reap the benefit of the special lectures and general training, although he cannot take a degree. For the benefit of librarians who cannot leave their posts of duty during the busy part of the year, summer courses are conducted, which have hitherto been largely attended.—C. S. Horton, in The New York Times.

ON THE POSITION OF HELIUM, ARGON, AND KRYPTON IN THE SCHEME OF ELEMENTS.*

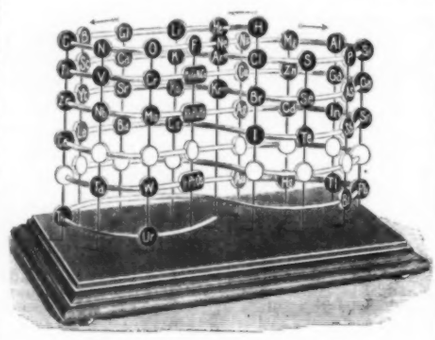
By Sir WILLIAM CROOKES, F.R.S.

IT has been found difficult to give the elements argon and helium (and I think the same difficulty will exist in respect to the gas krypton) their proper place in the scheme of arrangement of the elements which we owe to the ingenuity and scientific acumen of Newlands, Mendeléef and others. Some years ago, carrying a little further Professor Emerson Reynolds' idea of representing the scheme of elements by a zigzag line, I thought of projecting a scheme in three dimensional space, and exhibited at one of the meetings of the Chemical Society† a model illustrating my views. Since that time I have rearranged the positions then assigned to some of the less known elements in accordance with later atomic weight determinations, and thereby made the curve more symmetrical.

Many of the elemental facts can be well explained by supposing the space projection of the scheme of elements to be a spiral. This curve is, however, inadmissible, inasmuch as the curve has to pass through a point neutral as to electricity and chemical energy twice in each cycle. We must, therefore, adopt some other figure. A figure of eight will foreshorten into a zigzag as well as a spiral, and it fulfills every condition of the problem. Such a figure will result from three very simple simultaneous motions. First, an oscillation to and fro (suppose east and west); secondly, an oscillation at right angles to the former (suppose north and south); and thirdly, a motion at right angles to these two (suppose downward), which, in its simplest form, would be with unvarying velocity.

I take any arbitrary and convenient figure of eight, without reference to its exact nature; I divide each of the loops into eight equal parts, and then drop from these points ordinates corresponding to the atomic weights of the first cycle of elements. I have here a model representing this figure projected in space; in it the elements are supposed to follow one another at equal distances along the figure of eight spiral, a gap of one division being left at the point of crossing. The vertical height is divided into 240 equal parts, on which the atomic weights are plotted, from H = 1 to Ur = 239·59. Each black disk represents an element, and is accurately on a level with its atomic weight on the vertical scale.

The accompanying figure, photographed from the solid model, illustrates the proposed arrangement.



The elements falling one under the other along each of the vertical ordinates are shown in the table:

H	He	Li	Gl	B	C	N	O	F	Na	Mg	Al	Si	P	S
Cl	Ar	K	Ca	Sc	Ti	V	Cr	Mn·Fe·Ni·Co	Cu	Zn	Ga	Ge	As	Se
Br	Kr	Rb	Sr	Yt	Zr	Nb	Mo	Rh·Ru·Pd	Ag	Cd	In	Sn	Sb	Te
I	—	Cs	Ba	La	Ce	( )	( )	( )	( )	( )	( )	( )	( )	( )
( )	—	( )	( )	( )	( )	Ta	W	Ir·Pt·Os	Au	Hg	Tl	Pb	Bi	—
—	—	—	—	—	Th	—	Ur	—	—	—	—	—	—	—

The bracketed spaces between cerium and tantalum are probably occupied by elements of the didymium and erbium groups. Their chemical properties are not known with sufficient accuracy to enable their positions to be well defined. They all give colored absorption spectra and have atomic weights between these limits. Positions marked by a dash (—) are waiting for future discoveries to fill up.

Let me suppose that at the birth of the elements, as we now know them, the action of the vis generatrix might be diagrammatically represented by a journey to and fro in cycles along a figure of eight path, while simultaneously time is flowing on, and some circumstance by which the element-forming cause is conditioned (e. g., temperature) is declining (variations which I have endeavored to represent by the downward slope). The result of the first cycle may be represented in the diagram by supposing that the unknown formative cause has scattered along its journey the groupings now called hydrogen, lithium, glucinum, boron, carbon, nitrogen, oxygen, fluorine, sodium, magnesium, aluminum, silicon, phosphorus, sulphur, and chlorine. But the swing of the pendulum is not arrested at the end of the first round. It still proceeds on its journey, and, had the conditions remained constant, the next elementary grouping generated would again be lithium, and the original cycle would eternally reappear, producing again and again the same fourteen elements. But the conditions are not quite the same. Those represented by the two mutually rectangular horizontal components of the motion (say chemical and electrical energy) are not materially modified; that to which the vertical component corresponds has lessened, and so, instead of lithium being repeated by lithium, the groupings which form the commencement of the second cycle are not lithium, but its lineal descendant, potassium.

It is seen that each coil of the lemniscate track crosses the neutral line at lower and lower points. This line is neutral as to electricity and neutral as to chemical action. Electro-positive elements are generated on the northerly or retreating half of the swing, and electro-negative elements on the southerly or approaching half. Chemical atomicity is governed by distance from the central point of neutrality; monatomic elements being one remove from it, diatomic elements two removes, and so on. Paramagnetic elements congregate to the left of the neutral line, and diamagnetic elements to the right. With few exceptions, all the most metallic elements lie on the north.

Till recently chemists knew no element which had not more or less marked chemical properties, but now, by the researches of Lord Rayleigh and Prof. Ramsay, we are brought face to face with a group of bodies with apparently no chemical properties, forming an exception to the other chemical elements. I venture to suggest that these elements, helium, argon, and krypton, in this scheme naturally fall into their places as they stand on the neutral line. Helium, with an atomic weight of four, fits into the neutral position between hydrogen and lithium. Argon, with an atomic weight of about forty, as naturally falls into the neutral position between chlorine and potassium. While krypton, with an atomic weight of about eighty, will find a place between bromine and rubidium.

See how well the analogous elements follow one another in order: C, Ti, and Zr; N and V; Gl, Ca, Sr, and Ba; Li, K, Rb, and Cs; Cl, Br, and I; S, Se, and Te; Mg, Zn, Cd, and Hg; P, As, Sb, and Bi; Al, Ga, In, and Tl. The symmetry of these series shows that we are on the right track. It also shows how many missing elements are waiting for discovery, and it would not now be impossible to emulate the brilliant feat of Mendeléef in the celebrated cases of Eka-silicon and Eka-aluminum. Along the neutral line alone are places for many more bodies, which will probably increase in density and atomic weight until we come to inert bodies in the solid form.

Four groups are seen under one another, each consisting of closely allied elements which Prof. Mendeléef has relegated to his eighth family. They congregate round the atomic weight 57, manganese, iron, nickel, and cobalt; round the atomic weight 103, ruthenium, rhodium, and palladium; while lower down round atomic weight 195 are congregated osmium, iridium, and platinum. These groups are interperiodic because their atomic weights exclude them from the small periods into which the other elements fall, and because their chemical relations with some members of the neighboring groups show that they are interperiodic in the sense of being formed in transition stages.

NOTE, June 22, 1898.—Since the above was written, Prof. Ramsay and Mr. Travers have discovered two other inert gases accompanying argon in the atmosphere. These are called neon and metargon. From data supplied me by Prof. Ramsay, it is probable that neon has an atomic weight of about 22, which would bring it into the neutral position between fluorine and sodium. Metargon is said to have an atomic weight of about 40; if so, it shares the third neutral position with argon. I have marked the positions of these new elements on the diagram.—Chemical News.

PROFITABLE TOILET PREPARATIONS.

THE manufacture of toilet preparations, colognes, extracts, etc., by the pharmacist is not at all a difficult matter, yet it is surprising that it is given so little thought by them. The outlay for the necessary labels and glassware need be no hindrance, as they can be bought at a comparatively small cost, and the finished preparations will more than repay any enterprising pharmacist who will put forward a line of his own preparations under his label and guarantee. I give below a few tried formulas, some of which I have culled from different sources and some being original formulas of my own.

Should any of my confrères recognize among this list formulas which they have contributed to the various journals, I hope they will appreciate the fact that those formulas have been of use to one of their professional brethren, and hereby tender them my thanks for the same. The store in which these formulas and hints are used will enjoy the distinction of being up to date so far as its own preparations are concerned.

Every pharmacist, in looking over his stock, will be surprised to find out how many things he has that can be put to good use; for instance, the many fancy cologne and extract bottles which are stored away in odd corners and lockers. Collect them all, have them thoroughly cleansed and fitted with glass stoppers; then get your wife or (if you don't happen to possess that charming adjunct to a man's happiness) some female member of your family to cover each one with some colored satin or watered silk; then fill them up with your own cologne, extract, or toilet water, cap with kid or gold beaters' skin, and tie the neck with ribbon. Now, don't be surprised if they begin to sell at a much greater profit than you ever thought to derive from them. Recollect that there are many articles which sell themselves—that is, if properly displayed on your shelves and counters or, better still, on top of your showcases; your customers will see them, and having seen, will buy.

I will say, however, before going further: Have the best; let your component parts, be they essential oils, waxes, chemicals, or drugs, be the best that money can buy; and don't be afraid to use kid, gold beaters' skin, ribbons, artistic papers, seals, or any accessory which will tend to increase the attractiveness of your packages.

The following formula gives a cologne which closely resembles the famous Johann Maria Farina, gegenueber dem Juelichs-Platz, has a delightful odor, and really is a refreshing perfume:

FARINA COLOGNE.

Oil bergamot	10 c. c.
Oil neroli bigarade	15 "
Oil citronella	5 "
Oil cedrat	5 "
Oil rosemary	1 "
Tincture ambergris (1:32)	5 "
Tincture benzoin	5 "
Cologne spirit	800 "
Water	200 "

Let stand one week and filter through bone black. Put up in four, eight, and sixteen ounces, Caswell squares. Moisten a piece of gold beaters' skin in water and draw tightly over the stopper, tying it with fancy colored silk ribbon, very narrow, or silk twine. (Don't use sea island twine, as it looks cheap.) Label, and

* A paper read before the Royal Society, June 9, 1898.

† Presidential address to the Chemical Society, March 28, 1898.

lastly, cut a piece of parchment paper, large enough to wrap the bottle in; moisten the paper well with water, crumpling it in the hand like a sponge; then spread it on a smooth, clean surface and wipe off the excess of water; then wrap the bottle as tightly as you can in the paper, pasting together lightly; now fold the bottom first, then the top, and tie with silk twine or ribbon from top to bottom on each side and then around the neck, making the paper conform to the shape of the bottle, and leaving the ends of the cord long enough to seal to the shoulder with a fancy seal or sealing wax.

When the parchment dries, you have an elegant and refined package.

RICE POWDER.

Starch	3 pounds.
Rice flour	1 "
Perfume	q. s.

Mix thoroughly and pass through a sieve. Make a mould or use a package of Lubin's powder for the purpose. Now take sheets of stiff manila paper, cut to the proper size, and fold them on the mould, pasting or sealing the sides and bottom and folding the top so that it can be opened. Fill your cartons with the powder, fold the top and seal it, and then wrap in any embossed or fancy paper. (I used a watered silk paper, Peruvian gold, and Nile green.)

This is a good twenty-five-cent seller.

ALMOND MEAL.

Sweet almonds	16 ounces.
Florentine orris	8 "
Rice flour	16 "
Soap, dry	2 "
Borax	2 "
Oil bitter almond	q. s.

Bleach the almonds and dry in an oven, then reduce to powder in a mortar. Mix well with the other ingredients in fine powder and pass through a coarse sieve. Put in either tin almond meal boxes or an oblong telescope powder box holding three or four ounces. With a neat label, tie with ribbon, and seal.

HELIOTROPE GLYCERIN LOTION.

Glycerin	16 fluid ounces.
Water, distilled	16 " "
Borax	2 drachms.
Extract white heliotrope	q. s.

Mix and filter. Put up in three ounce Blakes, label to cover sides and front, cap with gold beaters' skin, but pasted on, not tied. In pasting the skin, spread it wet as for tying, but first apply the brush to the under side of the tip of the bottle, spread and tie until it dries, and then with a sharp knife trim evenly all around.

This is a steady seller at twenty-five cents.

BAY RUM.

Oil bay	10 drachms.
Oil pimento	1 "
Acetic ether	2 fluid ounces.
Alcohol	3 gallons.
Water	21½ "

Let stand one week and filter through magnesia. Put up in four, eight, and sixteen ounce bottles, Caswell style, wrapped in parchment, like cologne.

ALMOND CREAM.

Spermaceti	4 drachms.
White wax	2 "
White Castile soap	2 "
Blanched sweet almonds	4 ounces.
Alcohol	6 fluid ounces.
Rose water	16 " "
Oil rose	6 drops.

Rub the almonds with the water, then melt the wax and spermaceti by means of a water bath; mix the two, then slowly add the alcohol in which the oil of rose has been dissolved, and finally strain through cheese cloth. Put in six ounce short Blakes, label to cover front and sides. Cap the cork with kid, and tie with very narrow ribbon.

A good fifty cent seller.

GLYCEROSA JELLY.

French gelatin	1 ounce.
Glycerin	3 fluid ounces.
Rose water	10 " "
Oil rose	6 drops.

Melt together by the aid of a water bath, and add the oil. Put in collapsible tubes with label extending the entire length and turned in with the bottom of the tube.

EAU DE QUININE.

Quinine sulphate	3 gm.
Tincture cantharides	10 c. c.
Glycerin	75 "
Alcohol	550 "
Tincture krameria	15 "
Spirit lavender	50 "

Mix and filter. Put in six and twelve ounce Bartlett round bottles with sprinkler top.

BRILLIANTINE.

Virgin olive oil	8 fluid ounces.
Toilet water (any description)	4 " "

Put in brilliantine style bottles, two ounce size, and cap with kid.

ELDER FLOWER CREAM.

White wax	2 ounces.
Spermaceti	2 "
Oil sweet almond	14 fluid ounces.
Lanolin	6 ounces.

Melt together on a water bath and stir until nearly cold, gradually adding

Borax	75 grains.
dissolved in	
Elder flower water	9 fluid ounces.
Perfume with	
Oil bergamot	15 minims.
Oil rose	15 "
Oil neroli bigarade	10 "
Oil ylang-ylang	2 "
Oil orris	1 "
Tincture musk	5 "
Coumarin	½ grain.
Vanillin	3 "

Mix the oils and add to the melted waxes and oil. Dissolve the coumarin and vanillin in a portion of the oil of almond and treat likewise. Put in fancy glass or porcelain jars, with handsome label, and tie with ribbon.

TOOTH WASH.

Castile soap, white	2 ounces.
Glycerin	2 fluid ounces.
Water	4 " "
Alcohol	8 " "
Oil peppermint	20 drops.
Oil wintergreen	40 "
Cochineal coloring	q. s.

Mix and filter. Put up in two ounce flat, sprinkler-top, tooth wash bottles.

This sells at sight for twenty-five cents.

LAVENDER WATER.

Oil lavender flower	4 fluid ounces.
Cologne spirit	5 pints.
Water	1 "

LAVENDER WATER, AMBRÉ.

Lavender water	1 pint.
Tincture ambergris (1 drachm to 1 pint)	1 pint.
Coloring	q. s.

Filter through magnesia and put in toilet water bottles. Cap with kid and tie with narrow ribbon.

VIOLET WATER.

Spirit ionone (10 per cent.)	30 drops.
Distilled water	5 fluid ounces.
Orange flower water	1 " "
Rose water	1 " "
Cologne spirit	8 " "

Add the spirit of ionone to the alcohol and then add the waters. Let stand and filter.

WITCH HAZEL JELLY.

French gelatin	2 ounces.
Glycerin	6 fluid ounces.
Distilled extract witch hazel	20 " "

Dissolve the gelatin in the glycerin and witch hazel by means of a water bath. Perfume may be added. Put in collapsible tubes.

FLORIDA WATER.

Oil lavender	2 drachms.
Oil lemon	3 "
Oil bergamot	2 "
Oil neroli bigarade	1 "
Oil cloves	1 "
Oil melissa	30 minims.
Oil rose	6 drops.
Cologne spirit	26 fluid ounces.
Water	6 " "

Dissolve the oils in the cologne spirit and add the water. Let stand one week and filter through magnesia. Put in regular Florida water bottles, with tin foil cap.

AROMATIC TOILET VINEGAR.

Alcohol	6 fluid ounces.
Oil bergamot	25 minims.
Oil lemon	25 "
Oil orange	10 "
Oil rosemary	30 "
Oil lavender	3 "
Oil melissa	5 "
Decoction of 1 drachm each of benzoin, tolu, styrax, and cloves	12 fluid ounces.
Vinegar	4 " "
Acetic acid	1 fluid drachm.

Macerate one week and filter. Put in tall square or round bottle and cap with kid. Use neat label.

SACHET POWDER.

Frangipanni.

Florentine orris	6 ounces.
Vetivert	1 "
Sandalwood, E. I.	1 "
Oil rose	10 minims.
Oil sandal	10 "
Musk	30 grains.

Violet.

Florentine orris	6 ounces.
Benzoin	2 "
Spirit almond	2 minims.
Spirit ionone (10 per cent.)	30 "

Heliotrope.

Florentine orris	4 ounces.
Red rose leaves	2 "
Tonka	1 "
Vanilla	½ "
Musk	10 grains.
Spirit almond	40 minims.

Put up in sachet powder envelopes, with a layer of absorbent cotton to fit the envelope.

DENTAPASTE.

Florentine orris	40 ounces.
Myrrh	1 "
Pumice	1 "
Precipitated chalk	8 "
Oil clove	1 fluid drachm.
Oil lemon	1 " "
Oil rose	12 minims.

Honey, glycerin, equal parts, enough to make a paste. Solution carmine, enough. Put in collapsible tubes.

SEL NEAPOLITAIN.

Ammonium carbonate, in small pieces	8 ounces.
Ammonia water (10 per cent.)	4 "

Put in two ounce glass stoppered vials and fill with spirit of lavender (1:16). Violet, rose, heliotrope, or any odor can be made by simply adding the extract to the salt. Cap the bottles with kid and ribbon.

In conclusion, I would say that the attractiveness of the above packages will be purely a matter of taste with the maker, and if at first you find it difficult to wrap a bottle in parchment, or to cap one with kid and ribbon, don't give up, but try again until you do. I shall be more than glad to be of service to my pharmaceutical brethren at any time, and will be glad to furnish any formula in my possession if they will communicate with me. Should any of the above suggestions or formulas be of use to any of them, I shall feel amply repaid for the trouble of compiling and formulating them.—H. G. Posey, in Western Druggist.

NEW CONSTITUENT OF ATMOSPHERIC AIR.*

By WILLIAM RAMSAY, F.R.S., and M. W. TRAVERS.

THIS is inteuded merely as a brief résumé of experiments made during the past year to determine whether, in addition to nitrogen, oxygen, and argon, there are any gases in the air that have escaped observation owing to their being present in very minute quantity.

We have found that the nitride of magnesium, resulting from the absorption of nitrogen from atmospheric air, on treatment with water, yields only a trace of gas; that gas is hydrogen, and arises from a small quantity of metallic magnesium unconverted into nitride. That the ammonia produced on treatment with water is pure has already been proved by the fact that Lord Rayleigh found that the nitrogen obtained from it had the normal density. The magnesia, resulting from the nitride, yields only a trace of soluble matter to water, and that consists wholly of hydroxide and carbonate. So far, then, the results have been negative.

Recently, however, owing to the kindness of Dr. W. Hampson, we have been furnished with about 750 c. c. of liquid air, and, on allowing all but 10 c. c. to evaporate away slowly, and collecting the gas from that small residue in a gas holder, we obtained, after removal of oxygen with metallic copper and nitrogen with a mixture of pure lime and magnesium dust, followed by exposure to electric sparks in presence of oxygen and caustic soda, 26·2 c. c. of a gas showing the argon spectrum feebly, and, in addition, a spectrum which has, we believe, not been seen before.

We have not yet succeeded in disentangling the new spectrum completely from the argon spectrum, but it is characterized by two very brilliant lines, one almost identical in position with D_3, and almost rivaling it in brilliancy. Measurements made by Mr. E. C. C. Baly, with a grating of 14,438 lines to the inch, gave the following numbers, all four lines being in the field at once:

D_1	5895·0
D_2	5889·0
D_3	5875·9
D_4	5867·7

There is also a green line, comparable with the green helium line in intensity, of wave length 5568·8, and a somewhat weaker green, the wave length of which is 5560·6.

In order to determine as far as possible which lines belong to the argon spectrum, and which to the new gas, both spectra were examined at the same time with the grating, the first order being employed. The lines which were absent, or very feeble, in argon have been ascribed to the new gas. Owing to their feeble intensity, the measurements of the wave lengths which follow must not be credited with the same degree of accuracy as the three already given, but the first three digits may be taken as substantially correct:

Violet	4317
"	4387
"	4461
"	4671
Blue	4736
"	4807
"	4830
"	4834
"	4909
Green	5560·6
"	5568·8
Yellow	5829
"	5867·7
Orange	6011

Mr. Baly has kindly undertaken to make a study of the spectrum, which will be published when complete. The figures already given, however, suffice to characterize the gas as a new one.

The approximate density of the gas was determined by weighing it in a bulb of 32·321 c. c. capacity, under a pressure of 521·85 mm., and at a temperature of 15·95°. The weight of this quantity was 0·04213 grm. This implies a density of 22·47, that of oxygen being taken as 16. A second determination, after sparking for four hours with oxygen in presence of soda, was made in the same bulb; the pressure was 523·7 mm., and the temperature was 16·45°. The weight was 0·04228 grm., which implies the density 22·51.

The wave length of sound was determined in the gas by the method described in the "Argon" paper. The data are:

	1	2	3
Wave length in air	34·17	34·30	34·57
" " gas	29·87	30·13	....

Calculating by the formula

$$\lambda^2_{air} \times \text{density}_{air} : \lambda^2_{gas} \times \text{density}_{gas} :: \gamma_{air} : \gamma_{gas}$$

$$(34·33)^2 \times 14·479 \;:\; (30)^2 \times 22·47 \;::\; 1·408 : 1·666$$

it is seen that, like argon and helium, the new gas is monatomic, and therefore an element.

From what has preceded, it may be concluded that the atmosphere contains a hitherto undiscovered gas with a characteristic spectrum, heavier than argon, and less volatile than nitrogen, oxygen, and argon; the ratio of its specific heats would lead to the inference that it is monatomic, and therefore an element. If this conclusion turns out to be well substantiated, we propose to call it "krypton" or "hidden." Its symbol would then be Kr.

It is, of course, impossible to state positively what position in the periodic table this new constituent of our atmosphere will occupy. The number 22·51 must be taken as a minimum density. If we may hazard a conjecture, it is that krypton will turn out to have the density 40, with a corresponding atomic weight 80, and will be found to belong to the helium series, as is, indeed, rendered probable by its withstanding the action of red hot magnesium and calcium on the one hand

* Read before the Royal Society, June 9, 1898.

and on the other of oxygen in presence of caustic soda, under the influence of electric sparks. We shall procure a larger supply of the gas, and endeavor to separate it more completely from argon by fractional distillation.

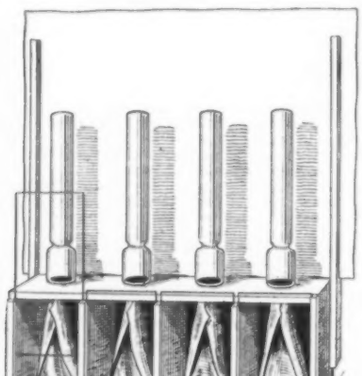
It may be remarked in passing that Messrs. Kayser and Friedländer, who supposed that they had observed λ_2 in the argon of the atmosphere, have probably been misled by the close proximity of the brilliant yellow line of krypton to the helium line.

On the assumption of the truth of Dr. Johnstone Stoney's hypothesis that gases of a higher density than ammonia will be found in our atmosphere, it is by no means improbable that a gas lighter than nitrogen will also be found in air. We have already spent several months in preparation for a search for it, and will be able to state ere long whether the supposition is well founded.

A SMOKE DETECTOR.

Written for Mines and Minerals by Capt. R. M. HASELTINE, Chief Mine Inspector of Ohio.

THE introduction into the mines of highly adulterated oil forced the Ohio Department of Mines to adopt some method whereby the extent of adulteration could be accurately detected. Early in the crusade against adulterated oil several devices were constructed with a view of subjecting the oil to a smoke test, none of which met the requirements, and all were cast aside. Later on chemical analysis was adopted as the most reliable means of determining the suitability of oil for use in the mines. This, however, proved inefficient, as the formulæ adopted by the department, although quite rapid in securing results, were too intricate excepting for laboratory work, and it required so long a time to secure samples shipped from distant parts of the State, that results were of no avail when obtained. Eight years of experience showed the necessity of providing each member of the department with a device simple in construction and accurate in results. The discarded devices were collected and the results of early experiments compiled and delivered to District Inspector Alexander Beattie, who entered the laboratory with instructions to develop a plan, which was afterward adopted.



SMOKE TESTER.

The method of determining the relative quantity of smoke generated by the several brands of miners' lamp oil is by a comparison with a pure oil. This is accomplished by the aid of a smoke furnace (so called) which can contain as many chambers as desired. The one here shown contains four compartments and is constructed from a box 21 inches in length, 11 inches in height, and 5½ inches in width, open on one side. This is subdivided into four compartments, each one 4⅛ inches in width. A tin funnel extends from within 2 inches of the bottom of the box, through a 1½-inch hole in the top, the top of this funnel being designed so as to hold the chimneys (which are of the student's lamp pattern) in place. In order to more accurately detect the volume of smoke, a white background, 18 inches in height, has proved of service. When but a slight difference occurs in oils under test, the glass shield provided for the front should be closed, a ¾-inch hole in the rear then furnishing the necessary oxygen. In making a test, it is necessary to select lamps of the same size and pattern. The wick must contain the same number of strands and a new wick should be used for each test. After the smoke of the wick has been burnt off, reduce the flames to the same size and place the lamps in the furnace, when the relative quantity of smoke generated will be easily detected. By using a four-chamber furnace, samples of different or two samples of the same oil can be tested at a time, or a sample can be placed between two samples of standard oil. Owing to the simplicity in the design of the furnace, it can be operated at any place and by any one who is familiar with the use of the miner's lamp, and the relative quantity of smoke generated by the several brands of miner's lamp oil can then be readily detected.

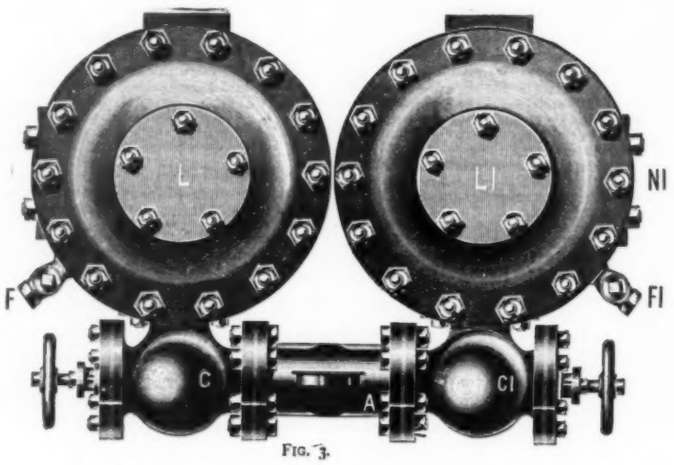


FIG. 3.

THE REEVES TWIN FEED-WATER FILTER.

IN the accompanying illustrations we show the latest type of the Reeves patent feed-water filter, as manufactured by the Reeves Patent Filters Company (Limited), Westminster, London, S.W.

As its name implies, this is a dual-chambered filter, the cylindrical chambers being coupled together by the "inlet" and "outlet" valve branches. Referring to the illustrations, *A* is the feed-water inlet bend, *B* the feed-water outlet bend, *C* and *CI* the inlet valves, *D* and *DI* the outlet valves, *E* and *EI* the straight through blow-out valves, *F* and *FI* the hot water jet cocks (connected to water space on the boiler), *G* and *GI* the drain cocks, *H* the inlet cone, *J* the outlet cone, *K* the triple gauze cone, *L* and *LI* the charging hole covers, *M* the coarsely granulated soft wood sawdust, and *N* and *NI* the hand hole covers. The cylinders are fitted internally, top and bottom, with open-ended perforated wrought steel cones, *H* and *J*, the space between the cones being tightly packed with coarsely granulated soft wood sawdust, *M*. The bottom or outlet perforated cones, *J*, are covered on their inner sides with triple gauze cones, *K*, to prevent the possibility of the escape of any of the absorbent filtering material. The water from the hot well enters the two chambers simultaneously through the common inlet bend, *A*, and the coupled inlet valves, *C* and *CI*, passing thence through the top perforated cones, *H*, it permeates the sawdust and escapes through the gauze cones, *K*, the bottom perforated cones, *J*, out through the coupled outlet valves, *D* and *DI*, and the common outlet bend, *B*, to the boiler. Hot water "jet" cocks, *F* and *FI*, connected to the water space on the boiler, are fitted to the top or inlet end of each chamber, and straight through "blow-out" or sluice valves, *E* and *EI*, are fitted to the bottom of each chamber communicating direct with the internal space containing the absorbent filtering material, *M*. The "blow-out" valves, *E* and *EI*, may be connected to the ship's side or led into a convenient drain, into which the oil-laden sawdust may be discharged. The chambers may be worked conjointly or independently, either chamber providing a filtering "by-pass" to its fellow. Constant filtration is thus maintained, and it is beyond the control of the engineer in charge to at any time supply other than filtered water to the boiler. The action taking place during filtration is as follows:

The oily water upon entering the filter permeates the porous granulations of the sawdust through and through, so that both oil and water are absorbed. The sawdust, however, having a special affinity for greasy matters, retains the oil, allowing the water alone to

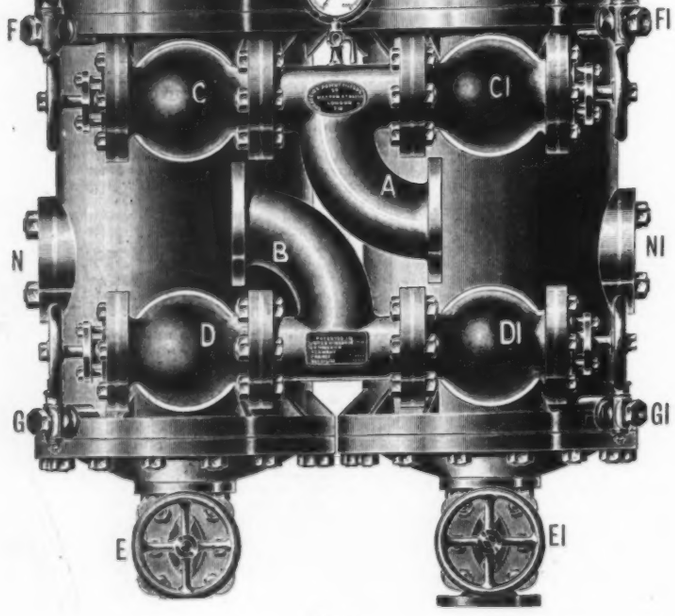


FIG. 1.

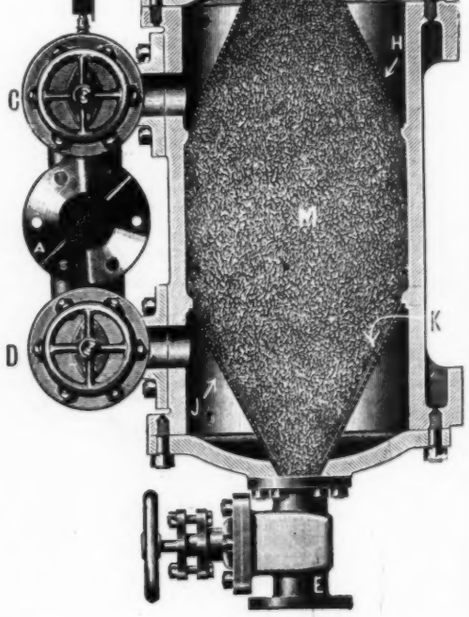


FIG. 2.

THE REEVES TWIN FEED-WATER FILTER.

pass in a purified condition. As the sawdust becomes saturated with oil, absorption ceases; the oily water then passes round the granulations instead of through them until it reaches a depth in the bed where the sawdust is unsaturated and absorption is still possible. Under ordinary conditions a fully charged filter will run for fourteen days without attention and do good work, but in all cases the life of the filtering medium is entirely dependent upon the quantity of oil held in suspension in the feed water.

The cleaning-out operation is performed as follows: The inlet and outlet valves, of whichever chamber it is desired to empty, are shut down, and the hot water "jet" cock from boiler is opened. The "blow-out" valve on the bottom is then opened full out, the oil-laden sawdust being almost immediately expelled. The hot-water "jet" cock and "blow-out" valve are then shut, the charging hole cover removed, and a fresh charge of sawdust (mixed with water to the consistency of a very thin porridge) poured in, the bottom drain cock being open during the filling process to allow the water to run off and the sawdust to settle down into a compact mass. When the filter is quite full of sawdust, the charging hole cover is replaced, the drain cock closed, and the chamber again placed in circuit. The other chamber may then be emptied and recharged in a similar manner.

A very large number of these filters have been supplied for marine and land use, and we understand that the company have numerous orders on hand.

We are indebted to The Steamship for the cuts and particulars.

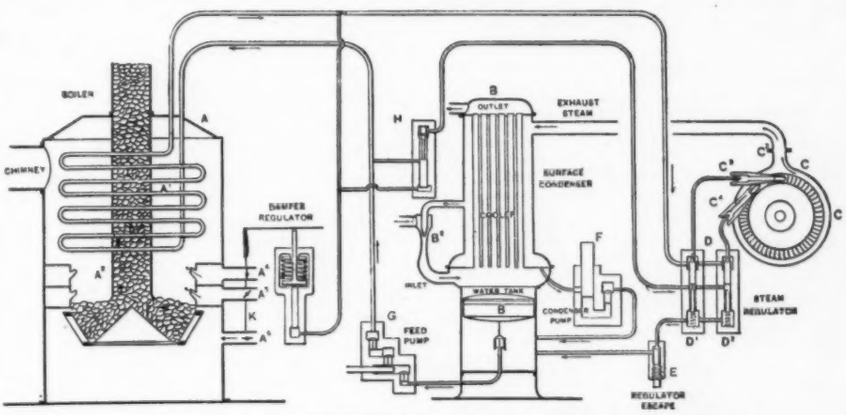
COMBINED ENGINES AND FANS FOR THE ADMIRALTY.

THE illustration shows one of the latest types of forced draught steam fans, made for the British Admiralty by Messrs Gwynne & Company, of Brooke Street Works, Holborn, E. C. The fans, which are open, of the double breasted type, are built of steel, and are designed to combine the greatest strength with lowest possible weight. The engines, which are very compact, are of strong construction, being suitable for running when desired with a steam pressure of 300 pounds per square inch, and also capable of performing full duty at 200 pounds pressure. Their normal speed is 500 revolutions per minute. The crank shafts are of best steel cut out of the solid, the connecting rods and eccentric rods of the highest grade of manganese bronze, and all the bearings and working surfaces are of exceptionally large proportions, to minimize wear under the trying tests of high speeds and pressures to which these engines are subjected in work. The ends of the fan spindles opposite to the engines are carried in bearings of special construction, having a universal adjustable provision to prevent strain of the spindles should the true alignment be disturbed from any cause. Every precaution has been taken to insure continuous lubrication of all the moving parts while the engines are running. We are indebted to London Engineer for the cut and copy.

THE DE LAVAL HIGH PRESSURE STEAM BOILER AND TURBINE.

IN order to give our readers a clearer idea of the high pressure steam boilers designed by Dr. De Laval and installed at the Stockholm Exposition we present the accompanying diagram, together with the following description taken from a late issue of Teknisk Tidskrift, showing how in "system De Laval" boiler and engine work together automatically so as to regulate the combustion and the steam pressure, the feeding of the boiler, etc., independent of the variation of the steam turbine.

The boiler, A, consists of a single long pipe of small diameter, bent in cylindrical spirals, A^1, between which the products of combustion pass, generating steam in the same. The fuel is fed at the top of the boiler, and is carried to the fireplace through the central tube, A^2, the lower end of which ends above a cone of masonry, A^3, which spreads the fuel on the surrounding basket-shaped grate. The air of combustion is forced into the fireplace by means of a blower, partly through the flue, A^4, which enters below the grate, and partly through A^5, from which the air is forced through mouthpieces immediately above the top level of the fuel. This air, therefore, answers the purpose of consuming the smoke as well. Should the steam pressure rise too high, the air supply through A^5 and A^6 is cut off, and air is instead forced in through A^4, whereby the combustibles are cooled off and the steam pressure lowered. This regulation of the combustion and steam pressure is accomplished by means



THE DE LAVAL HIGH PRESSURE STEAM BOILER AND TURBINE.

of the dampers in these three pipes which are manipulated by a system of lever, chains, and rollers, A^7, in the damper regulator, K, which consists of a piston, the steam pressure on which is counterbalanced by a spring. As soon as the steam pressure changes, the piston moves in one direction or another, and thus opens or closes said dampers. The water is fed to the boiler by the feed pump, G, which has several plungers (four in the 50 horse power system and six in the 100 horse power system) in order to furnish as even a supply of water to the boiler as possible. The suction pipe of the pump is connected with the water cistern, B^2, where the supply is regulated through the float, B^3, and which, thus, by the water level determines the amount of feed water to the boiler.

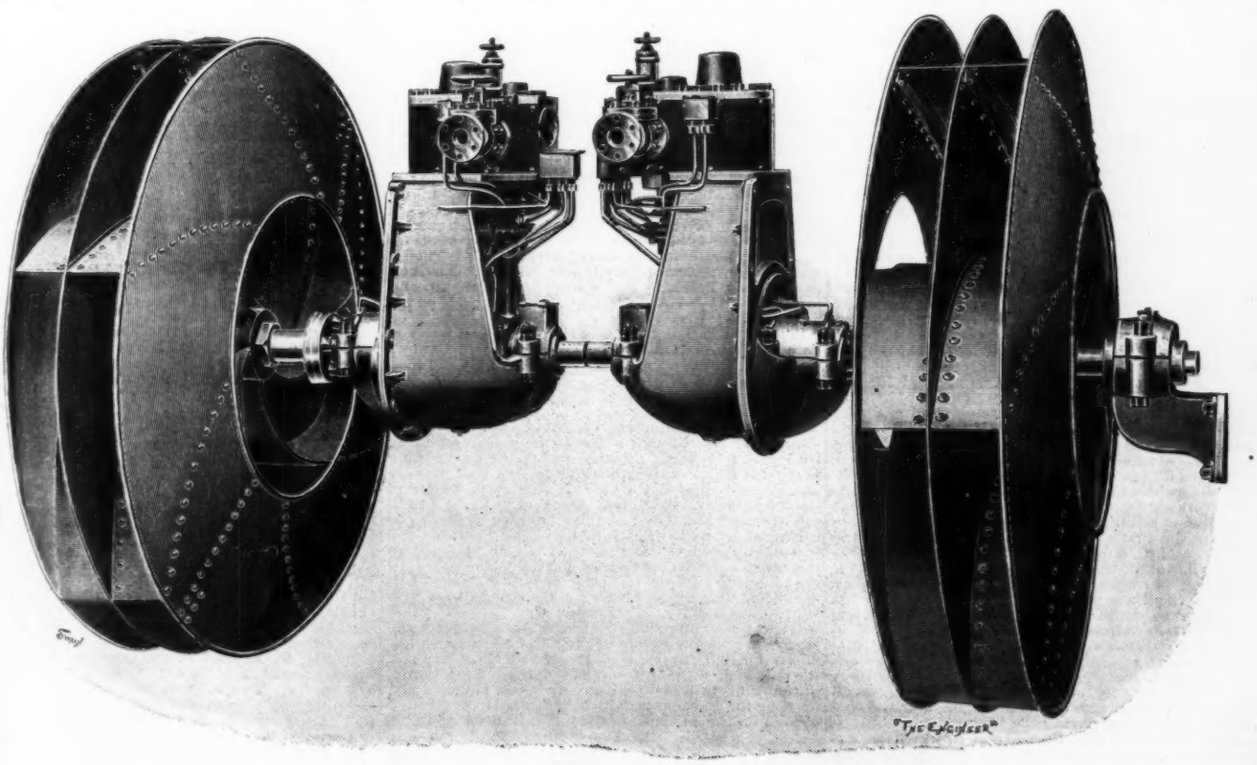
The steam generated in the spiral pipe at the exhibition plant had a temperature of 660° F., and a pressure of 1,735 pounds, which at the steam turbine was reduced to 1,420 pounds per square inch. The steam is first conducted to the regulators, D, which successively adjust the amount to the nozzles, C^3 and C^4, of the turbine, C. This regulation is accomplished by hydraulic pressure in the following manner. The pressure water is obtained from the discharge pipe of the feed pump to the boiler, passes a reducer, H, which reduces the pressure to that of the steam. From here it goes to the middle part of the steam regulators and drops around the piston down to the lower ends, D^1 and D^2, where the pressure of the water and the spiral springs is counterbalancing the steam pressure in the upper ends of the regulators. The pressure of the water in the lower ends of the steam regulators is determined by the regulator escape, E, which is opened and closed by a centrifugal regulator.

From the upper ends of the steam regulators the steam is conducted through four mouth pieces, or tuyères, C^3 and C^4, with very small apertures. The turbine disk, C^1, is constructed as a double turbine with two rows of buckets and a division wall. From the tuyères the steam passes first through one of the rows of buckets, then through the division wall, and finally through the other series of buckets. The disk rotates 13,000 revolutions per minute in a 100 horse power turbine and 16,400 revolutions in a 50 horse power one. These speeds are reduced by gearing to 1,050 and 1,500 revolutions respectively at the indicator shaft.

The exhaust steam from the turbines passes through the exhaust pipe, C^2, to the surface condenser, B, which is composed of vertical pipes and works with a vacuum. The condensed steam is forced into the hot water tank by the condenser pump, F. The condensers are freed from air by means of an ejector, B^5, placed in the cooling pipe going to the condenser. The feed pump as well as the condenser pump are worked direct or indirect by the turbines, as are also the pump for the cooling water and the fan (not shown on the diagram). These latter are coupled direct to the shaft of the inductor, and thus run at the same speed, 1,050 and 1,500 revolutions respectively, per minute, while the feed pump makes 300 and the condenser pump 130 strokes per minute.

Particularly noticeable at the power plant in question was the small floor space occupied by this combination of boiler, steam turbine, and dynamo, which, for the 100 horse power system, was only 19·7 feet by 11·5 feet and for a 50 horse power system 16·4 feet by 8·2 feet. The 100 horse power boiler, which generated 1,765 pounds of steam per hour, was 4·6 feet in diameter and 9·8 feet high, while the 50 horse power boiler had a diameter of 3·6 feet and a height of 8·5 feet and generated about 880 pounds of steam per hour.

Regarding the danger of explosion of the boiler under such enormously high pressure as used for obtaining this improved effect of the steam in the tur-



FORCED-DRAUGHT FANS FOR THE BRITISH NAVY.

bines, this is here reduced to a minimum by the exceedingly small diameter of the spiral pipe and consequent small volume of steam it contains, besides the absence of any large volume of water. The water, as it enters the spiral, is immediately converted into steam, and if the pipe should burst somewhere the steam in that part of the pipe would instantly escape, and so also successively the steam from the other parts of the boiler, until the whole contents has passed out through the chimney. Besides, these pipes are made of the very best material, drawn and hammered out from whole ingots and afterward cold pressed and tested under a pressure several times that expected to be carried.

Experimentally the pipes have been made to explode "directly in view of the operator" without causing any damage whatever.—The Iron Age.

THE PERFORMANCE OF THE "OREGON'S" ENGINES ON THEIR GREAT RUN OF 15,000 KNOTS.

WE are permitted to publish the following very interesting letter, says The New York Sun. It was written to a relative by one of the young men who have attained honor and distinction in our navy, First Assistant Engineer Cleland Nelson Offley, of the "Oregon's" starboard engine room. It sheds a little light, perhaps, upon a part of the ship and the ship's personnel that the public as yet inadequately understand.

U. S. S. "OREGON,"
BLOCKADING SANTIAGO DE CUBA,
June 22, 1898.

Knowing the great interest you take in all matters pertaining to our navy, and the especial interest with which you have followed our remarkable race for the scene of war, I am sure you will be pleased to have a more or less full account of our recent voyage, together with some general data. I will therefore start this account, making it from time to time as opportunity offers.

The "Oregon," you know, is a first class coast defense battleship of about 10,000 tons displacement at the so-called normal draught. In this condition, however, she has only a certain limited amount of stores on board and only 400 tons of coal. When she goes to sea with her bunkers full of coal, all stores, and all ammunition on board, her actual displacement is something over 12,000 tons, and her draught of water is then over 27 feet, and she was, of course, in this latter condition when we started out from San Francisco, having on board at that time about 1,500 tons of coal, all bunkers being practically full.

The ship is driven by twin screws, worked by triple expansion engines, the engines being placed in separate watertight compartments, and the tops of the cylinders come well below the protective deck. There are four large main boilers, double ended cylindrical, each boiler in a separate watertight compartment, and, of course, also well below the protective deck. These boilers are each 15 feet in diameter, 18 feet long and have eight furnaces, four in each end. The dimensions of each furnace are 3 feet diameter, and length of grate 5 feet 6 inches, giving a grate surface for each furnace of 17¼ square feet, or 552 for all main boilers.

We all knew, of course, that we had a remarkably fine ship, but before starting out we felt some little anxiety as to our ability to keep the machinery fully up to its work during such a long cruise. Nothing approaching it had ever before been attempted by a heavy battleship. Fortunately we had just come out of dry dock in Brewerton (and our trip should really be considered as starting from that point rather than from San Francisco) and were only nine or ten days in San Francisco before starting for Callao, just long enough to fill our bunkers and magazines. Our machinery, both engines and boilers, were then in excellent condition, everything having been thoroughly overhauled by our own people while in dry dock; so it was not necessary to do any great amount of work in San Francisco.

Having finally filled up with coal, ammunition, and stores, we left on March 19, and proceeded under three boilers direct for Callao, which port we reached on the morning of April 4, having expended during this run of sixteen days 900 tons of coal, leaving 600 tons still in our bunkers. This we consider a remarkably efficient performance, having averaged 4·24 knots per ton of coal. The revolutions of the engines during this run were remarkably steady, averaging 75 revolutions per minute for day after day without a variation of a tenth of a revolution.

On two different occasions one of the boilers in use began to leak slightly around the back ends of some of the tubes. On both occasions we immediately started fires in the idle boiler, and allowed those in the leaking boiler to die out, and as soon as possible the boiler maker was sent in to re-expand the tubes. During all this time the water in the boilers was perfectly fresh, our evaporators and distillers having a capacity of 5,000 gallons a day, which was sufficient for all purposes, including the necessary makeup feed for the boilers.

On the afternoon of March 27 smoke and gas were discovered to be coming out of one of the coal bunkers. This bunker was over half full at the time, having probably between 65 and 70 tons in it. There was nothing to do but dig for the fire, as it was evidently down somewhere in the body of the pile. So we started in, working a couple of men in the bunker for about 10 minutes at a time, and then sending in a couple more to relieve the first. After about two hours' work the fire was reached, only about a shovelful of live coal being found, but probably a couple of tons so hot that it was giving off smoke and gas. After about four hours' steady work, all the dangerous coal had been removed and no further trouble was encountered. We had to call for assistance from the deck force to help us out in carrying the coal away, as we kept up the speed of the ship the whole time; but our own men did all the work in the bunker itself. Naval Cadet Jenson, one of our engineer cadets, was temporarily relieved from watch duty and put in charge of the fire gang, and the way he went at it, never paying the least attention to the excessive heat and foul air and gas in which he was working, was wonderful to see.

On arriving at Callao we found that our coal had been ordered for us by the "Marietta." The lighters had all been loaded and were brought alongside as soon as we let go the anchor.

Then began some real work. I started in on the starboard engine and Reeves on the port engine, and we overhauled connections, scraped in brasses where necessary, examined, cleaned, and repaired air pumps, circulating pumps, wiped out and oiled all the main cylinders and valve chests. Fortunately for me, my engine was in pretty good shape, needing only a slight amount of keying up here and there. Reeves, however, found one of his main crosshead slippers so badly cut and scored that it was deemed best to remove it and put in place a spare one, which we carried on board. This sounds easy, but it required twenty-four hours' continuous work, as it had to be fitted exactly, the face carefully scraped to a true surface, and finally the guides nicely adjusted.

In the meantime the firemen and coal passers were engaged in trimming the bunkers, under the supervision of our two cadet engineers, who took twenty-four hours' watch at a time.

When we arrived here it was evident that war with Spain was inevitable, but war had not yet broken out. However, every precaution was taken to guard against any treachery on the part of Spanish sympathizers. The ordinary number of sentries was doubled and these men were armed with ball cartridges, ammunition was got up for the rapid-fire guns, and the steam launches were manned with armed crews and kept patrolling around the ship all night, to warn off and prevent any strange boats from approaching. These precautions were observed whenever we were at anchor in any port during the whole trip.

All our coal was finally on board by the afternoon of April 7, and out we started again, using three boilers and averaging something over 11 knots per hour, until the evening of the 9th, when the fourth boiler was put on and the average speed increased to about 13 knots, and this was kept up until the evening of the 16th, when we reached Port Tamar, just inside the entrance of the Straits of Magellan. We had a few leaky tubes in one boiler a day or so after leaving Callao, and of course stopped them as soon as possible. Soon after this, in some way which we have never been able to determine, a small amount of salt water got into our boilers, just enough to cause the density of the water to become about one-quarter of that of sea water. This, of course, meant a certain amount of scale, but, fortunately, the amount was so small that it merely served to make our tube ends tight, without being enough to cause any bad effects on the boilers. At all events, from that time until long after our arrival off Santiago we did not have another leaky tube.

We spent the night at anchor in Port Tamar, and the next morning started out with the intention of making Sandy Point by dark. This, of course, required a semiforced draught run, what is known technically as "assisted draught;" that is to say, the forced draught blowers are run, but the firerooms are not closed up airtight, as under full forced draught. We ran our blowers at such a speed as to give an air pressure of one-quarter of an inch of water, and were thus able to run the engines at a speed of 107·3 revolutions per minute, giving the ship a speed through the water of 14·6 knots per hour. As a matter of fact, our speed from point to point along the shore was much greater, as there was a very strong current running through the straits in our favor.

While at Callao we had heard that a Spanish torpedo boat was at Montevideo, and we thought it just possible that she might attempt to intercept us in the straits, lying behind one of the numerous high points and darting out on us. So the rapid-fire gun crews were kept at their guns, ready for instant work. However, we saw nothing of her.

Sandy Point was reached in the evening, and the next morning (April 18) began our usual work—coaling ship, cleaning, repairing, and overhauling machinery. Of course, the only way to keep the ship going was to turn to at every opportunity and do everything possible in the time allowed; but it was beginning to tell on all of us. We all had to stand watch at sea, and as soon as port was reached all hands of the engineer's force had to go at the work and keep it up, going for every little thing that showed the least sign of wear, and not waiting even for it to show, but hunting for things of which there was the least probability of their becoming out of order. But all hands stood the strain well.

We remained at Sandy Point until the morning of April 21, leaving with about 1,200 tons of coal in our bunkers. The "Marietta" accompanied us from Sandy Point to Rio, or rather until the morning of the 30th, when we increased our speed to about 14½ knots an hour, in order to arrive in port during the afternoon, leaving the "Marietta" to follow in later. The run from Sandy Point to Rio was without incident, and was at a slower speed than our previous runs, on account of the "Marietta."

It was at Rio that we received the news that war was on with Spain, and at the same time a rumor of Dewey's victory at Manila reached us. We also received a long cablegram from Washington, informing us that Admiral Cervera's squadron of four heavy armored cruisers and four seagoing torpedo boats had left for Cuban waters, and we were advised to avoid them if possible. We remained at Rio until May 4, doing what repairing we could and filling up with coal, taking something over 1,000 tons. During our stay in this port we were not allowed to visit the shore. Here, too, we found the "Nietheroy," which had been bought by an American firm and was flying our flag, and which was to be convoyed by us to the United States. However, she was not allowed to leave port with us, so we stood up the coast a few miles to wait for her. She joined us the following evening, but her boilers were in such bad condition that it was decided not to waste time with her; so she was left in charge of the "Marietta," and we went ahead, arriving at Bahia on the evening of the 8th. Here we put on our war paint and made arrangements for refilling our bunkers, but on the evening of the 9th a cablegram was received from Washington, ordering us to leave. So out we went immediately, heading for Barbadoes, which was reached at about 3 o'clock on the morning of May 18. Here we took 240 tons of coal and left the same evening, standing well to the eastward, and finally reached the Florida coast at Jupiter Light on the evening of the 24th, reporting our arrival to Washington. Orders came back to proceed to Hampton Roads if in need of repairs, otherwise to Key West. There was no hesitation as to which direction to take under these orders, and finally Key West was reached on the morning of the 26th, thus completing the most remarkable and successful performance ever undertaken by a battleship.

I have since heard that there was great anxiety among our own people at home on account of this ship and that foreign nations were watching our run with great interest, while many doubted our ability to successfully accomplish it.

In the first place, the machinery of this ship was beautifully and strongly built, and, above all, was erected in the ship with the greatest care and thoroughness. Great credit is therefore due to her builders and to the inspectors who supervised the work. From the day she went into commission the greatest care has been taken to keep everything up as nearly to perfection as possible. On the discovery of the least defect in any part it has been remedied immediately. Whenever a run has been made, no matter how short it may have been, on reaching port again the cylinders and valve chests, air pump valves, etc., have been carefully examined, cleaned, and oiled. The most careful attention has been paid to the condition of the boilers, and every endeavor has been made to avoid the use of salt water in them; that, indeed, is the point to which our success is largely due. Every leak, however small, in the boilers themselves, in the steam pipes, in the engines, or in the condensers, has been stopped just as soon as possible, and thus only has it been possible to keep down the amount of water necessary for make-up feed to such a point that our evaporators have been able to furnish it, in addition to the water required for all other purposes.

The following is a summary in tabular form of our runs, showing at a glance the number of knots run, the speed of the ship in knots per hour, the consumption of coal, and the knots run per ton of coal. The data in this table are taken from the time of getting fairly under way, the time while entering and leaving port being eliminated. The coal, of course, does not include that used while lying in port, but includes coal consumed for all purposes while at sea.

	Distance, Knots.	Time, Hours.	Speed, Knots per Hour.	Coal, Tons.	Knots Run per Ton of Coal.
Brewerton to San Francisco..	827·7	72	11·49	221·0	3·74
San Francisco to Callao.....	4,056·5	371	10·93	952·0	4·24
Callao to Port Tamar.....	2,529·9	212	11·93	785·0	3·22
Port Tamar to Sandy Point..	132·9	9	14·75	66·0	2·00
Sandy Point to Rio de Janeiro	2,217·7	223	10·08	657·0	3·42
Rio to Bahia	70·0	*	*	288·0	....
Bahia to Barbadoes.....	2,239·0	193	11·55	630·0	3·59
Barbadoes to Jupiter.....	1,683·9	142	11·86	478·5	3·3
Jupiter to Key West.....	280·0	27	10·37	77·9	3·6
Totals	14,706·7	....	....	4,155·4	....

*Speeds variable. Data unreliable.

C. N. OFFLEY.

It has been found that, when rubber is in contact with iron or steel, it remains practically unchanged for a considerable time; very different, however, is its behavior when used with copper or brass. Mr. Gilbert R. Redgrave, in a lecture before the Society of Arts, said that, when employed in a tube of copper or brass, it appears to undergo some chemical action which leads to its ultimate conversion into a resinous compound, devoid of elastic properties. Dr. Burghardt has pointed out that this deterioration is due to the action of oxygen, which is the great enemy of all kinds of rubber. Certain of the heavy coal tar oils, and many oils of animal origin, such as tallow oil, fish oil, etc., when brought into contact with India rubber, seem to set up the oxidizing process with fatal rapidity. Copper oxide, in conjunction with oil, is a source of peculiar danger to caoutchouc, and in the tubing formed of copper the destructive action has been observed in less than a year. For these purposes, therefore, when the use of a rubber strip is advisable, it is necessary to apply a protective coating of tin or some other metal on the surface of the copper to guard against this action. The India Rubber World, in commenting upon this, says that the coating of copper wires with tin before the insulating covering is applied is simply to guard against deterioration. At the same time this destructive tendency has been turned to advantage when it was necessary to stick rubber tightly to iron. It is the thin coating of copper on the iron axle of the wringer roll that joins the metal and the rubber so that it is almost impossible to separate them.

A valuable circular—No. 18—dealing with the physics of timber, has just been issued by Prof. B. E. Fernow, Chief of the Division of Forestry of the United States Department of Agriculture. The paper is given exceptional importance by the development of a formula worked out by Mr. S. T. Neely, showing how the strength of beams can be determined from the compression strength. In testing timber to obtain its various coefficients of strength, the test which is at once the simplest, most expedient, satisfactory, and trustworthy is the "compression endwise test," which is made by crushing a specimen parallel to the fibers. All other tests are either mechanically less easily performed or else, as in the case of cross bending, the stresses are complex, and the unit coefficient can be expressed only by depending upon a doubtful theoretical formula. It is, therefore, of great practical value to have a relation between the cross-bending strength—the most important coefficient for the engineer—and the compression strength, and this is what Mr. Neely has found. His discovery is expressed in the following conclusion: "The strength of beams at elastic limit is equal to the strength of the material in compression, and the strength of beams at rupture can be directly calculated from the compression strength; the relation of compression strength to the breaking load of a beam is capable of mathematical expression." This enunciation, says Nature, is of far reaching importance, and a comparison, if calculated with observed results given in the circular, is convincing as to the efficiency of the formula. It is to be hoped that other and similarly successful scientific investigations into the physics of timber will be made in the United States Division of Forestry.

ENGINEERING NOTES.

The **largest** whaleback ever built, the steamer "Alexander McDougall," left the slip at the Barge Works, West Superior, Wis., on August 3, and went to the Mesaba ore docks to load with 6,000 tons of ore for a maiden trip down the great lakes.

After eight years' work the five-mile-long tunnel through the Col di Tenda, in the Italian coast Alps, has been pierced through, in spite of serious engineering difficulties met with in the interior of the mountain. The railroad through the tunnel will be open for traffic at the beginning of 1900.

Old Suspension Bridge Cables.—Ten cables, each 1,060 feet long, which supported the old suspension bridge across the Niagara River, at Lewiston, which was wrecked 21 years ago by a heavy windstorm, were cut away recently and allowed to drop into the river. These cables had been swinging in the gorge since the bridge was wrecked. It was found necessary to get them out of the way to permit work on the new braced arch, closed several weeks ago, which is to take the place of the present highway suspension bridge below the falls.

The earliest form of mechanical stoker of which there is any record was the one patented in 1785 by James Watt. It consisted of two sets of horizontal grate bars, one behind the other, which were worked intermittently by means of levers operated by hand. The coal was fed in at the door, and pushed back as it became choked, the gases from the fresh fuel passing over and through the fuel in more advanced combustion on the bridge end of the grate. It was designed primarily to prevent smoke from bituminous coal, and was quite successful.

The transit facilities of New York city are reported upon by the State Railroad Commissioners for 1897. The report includes the railways of New York city, or the Boroughs of Manhattan and the Bronx. For these the receipts of the various railways for the year aggregated $25,000,000, of which sum $11,500,000 were collected by cable lines and their branches, $3,500,000 by horse car lines not operated as subsidiary to cable companies, and $750,000 by overhead trolley lines; the remainder, or about $9,250,000, represents the receipts of the elevated railway system.

A new compound of aluminum and zinc, called "alzine," was reported on by Prof. Carpenter, in a paper read before the American Society of Mechanical Engineers. This alloy is said to possess some very excellent qualities. The tensile strength of the material is from 24,000 pounds to 26,000 pounds per square inch. It is rigid, and possesses very little ductility. In Prof. Carpenter's opinion, it will serve as a substitute for cast brass in nearly every instance where cast brass is serviceable, but cannot take the place of soft or leaded brasses, since it possesses little ductility.

The Imperial Railway Company, of Ethiopia, who are building the line which is to open up the trade of Abyssinia with the French port of Jibutel, state that the first section from Jibutel to Harrar will be opened for traffic in the early months of next year, says The Mechanical Engineer. The first section is about 190 miles in length, and the main difficulties are encountered in the first 30 or 40 miles. Three viaducts are required in this distance, and the line climbs upward on to the Abyssinia plateau, after reaching which the rest of the route to Harrar offers no very great difficulties. The metal portions of the viaducts are being constructed in France, and will be completed by about the end of this summer. The second portion of the line, that which is to join Harrar to Addis Abeba, the Abyssinia capital, will be over 300 miles in length, and when it is completed there will still remain one other section covered by the concession which is to connect Addis Abeba with the Nile.

One of the most notable facts in railway construction has recently been developed in one of the far off regions of Sweden. After years of agitation, the Riksdag of that kingdom has voted a sufficient number of millions for the extension of the northern trunk line from the coast of the Baltic, across the Norwegian boundary, and up to Ofoden, on the shores of the Arctic Ocean. This, as a geographical fact, implies that such a railway line will be the northernmost in the world. Its Norwegian terminus is to be located close to latitude 69° north, which is 150 miles north of the Arctic circle, and, of course, on the same latitude as the middle part of Greenland and the northern shores of British North America, Alaska, and Siberia. The remarkable fact appears, however, that though this road is laid almost within sight of the Pole, it will lead to a harbor which, favored by the Gulf Stream, is open all the year round, and from which the valuable mineral treasures of Swedish Lapland may be shipped advantageously to all parts of the world.

An elevator shaft to the summit of Mont Blanc, with a shaft 1½ miles deep and a 3½ mile tunnel to the bottom of the shaft, is proposed by a French engineer, Paul Issartier, of Marseilles, says Engineering News. The tunnel would rise 600 feet in 18,864 feet, terminating 7,500 feet above sea level. The vertical shaft would be 10 by 13 feet, and have a depth of 8,200 feet, and he proposes to excavate it from below. He has devised a "rising chamber," made of strong steel plates, in two stories divided by steel doors; on the upper floor would be the rock drilling machinery, driven by compressed air. To avoid lowering the "chamber" out of the way of blasts, he would drill only on one side first, then roll the drilling machines to the other side and protect them by lifting steel doors. To catch the fragments of rock he proposes a series of strong steel gratings, placed at an angle of 45° and protected by fascines; these are supposed to permit the passage of the gases of explosives while retaining all the rock. On the lower story this rock would be "pulverized" and then passed down a 12 inch tube to the bottom of the shaft, and thence carried outside by a stream of water propelled by centrifugal pumps. The "chamber" would rest upon and be raised by strong steel racks placed in the four corners of the shaft. He presents no estimate of cost, and the proposition is chiefly interesting as a somewhat wild attempt to solve some novel engineering problems.

MISCELLANEOUS NOTES.

Increase in Japanese Exports.—From 1896 to 1897 the value of exports in silk (the most important Japanese export article) has increased almost 100 per cent. Cotton yarns, second in importance, show an increase of 240 per cent., tea 20 per cent., coal over 25 per cent., matches 14 per cent., straw 40 per cent., habutai 22 per cent., and copper 6 per cent.—Uhland's Wochenschrift.

The question of the porosity of thin steel plates under heavy hydraulic pressure having been raised, experiments have been carried out at the Washington Navy Yard, U. S. A., with the view of settling the point in a practical way. Pieces of sheet steel of ¼, ⅛, 1/16 and 1/32 inch in thickness were subjected to a water pressure of 6,000 pounds per square inch, and in no case was any percolation found. A ¾ inch rivet joining two ¼ inch plates also proved tight under the same pressure. A test was also made to determine the friction of water under high pressure, and, while it was inconclusive, there was no evidence that the friction of water under high pressure was any greater than the friction of water not under pressure.

The stars and stripes in the shape of the largest flag in the world will float over Morro Castle, Havana, when Blanco surrenders. The immense flag designed for this duty is already prepared by a patriotic Wall Street man. It measures 120 feet in length and 43½ feet in width, and it is believed that it breaks the record for size. It is so big that special bunting was made for it in Boston. The bunting measures 42 inches across in the rough. Made up in the flag, allowing for seams, each stripe measures 40 inches. It took a full piece of forty yards for each stripe, except where they run into the jack. The jack measures 40 feet in length and covers the space of seven stripes. The stars are not very large. From point to point each star measures 14 inches. They are arranged in alternating rows of seven and eight, according to army regulations. The flag will cost $290. Big as it is, it can be packed in a large traveling trunk and will not weigh more than 200 or 250 pounds.

Boiler Explosions in Great Britain.—The total number of cases dealt with under the boiler explosion acts during the year ended June 30, 1897, was 80, and by these explosions 27 persons were killed and 75 injured. This represents a total of 102 persons killed and injured during the year, and exceeds the average (90·5) for the 15 years during which the act of 1882 has been in operation by about 12·7 per cent. The loss of life, taken alone, closely approximates to the average (28·6) for the same period. The causes of explosion show no important variation. Of the 80 cases dealt with, 28 were attributed to the defective condition of the boiler or of its fittings, 33 to defective design, workmanship, material or construction or to undue working pressure, and 12 to ignorance or neglect of the attendants. In 42 cases the boilers were under the inspection of some public association, or were used in vessels provided with Board of Trade passenger certificates, but in many of these cases the explosions were not due to defects which existed when the last periodical inspection was made.

H. T. Newcomb has prepared for the United States Department of Agriculture a statement showing that the decline in rates of freight per ton per mile has been as follows:

1867	1·925	1882	1·102
1868	1·810	1883	1·205
1869	1·709	1884	1·136
1870	1·889	1885	1·011
1871	1·789	1886	0·999
1872	1·846	1887	0·984
1873	1·613	1888	0·941
1874	1·520	1889	0·922
1875	1·421	1890	0·941
1876	1·217	1891	0·895
1877	1·286	1892	0·898
1878	1·296	1893	0·878
1879	1·153	1894	0·860
1880	1·232	1895	0·839
1881	1·188	1896	0·806

The decline in 30 years therefore has been from about 2 cents to 8 mills—or a fall of 58 per cent. Even this does not represent the whole of the actual decline, because for the earlier years the records are incomplete and the roads on which the rates are not now ascertainable are those with which the least business had the highest rates. The real average for the country in those days was undoubtedly even higher than the figures indicate. Taking the figures as they are, however, the report says that the decrease "is probably not exceeded by that in the price of any important commodity among those largely shipped by rail."

The following letter, from Mr. T. M. Richards, of Boca Ratone, Fla., to Mr. James E. Ingraham, Land Commissioner of the Florida East Coast Railway, will prove of interest to fruit growers throughout the State. "Referring to our conversation concerning protection against frost for vegetables and pineapples, I would suggest the plan commonly in use, and very successfully so, in parts of Carolina and Virginia, as follows: In the fall, some weeks before danger of cold, one should procure a supply of pine sawdust from the mills. Around each field of not more than four acres' area (and two acres is better) the sawdust should be deposited in conical piles, fifty feet apart, and two bushels of sawdust in each heap. These heaps should be placed all the way around each lot, as the wind may shift to any quarter. When the thermometer shows danger of frost at three o'clock in the morning, let men take cans of common kerosene and go to each alternate heap, make a little opening in the top of the heap, pour in one or two tablespoonfuls of kerosene, and set it on fire. It will not blaze much, but by giving a little time for the oil to spread before firing, the sawdust will smoulder and burn slowly until it is all consumed, all the while smoking forth volumes of thick smoke, which will protect the plants from the direct rays of the sun, and prevent them from scalding until frost is slowly drawn out. Last winter's freeze in many instances demonstrated that the sun was responsible for the damage in nearly every case. Wherever there was shade through the forenoon no plants were injured. This is also the case among the orange groves in the interior. This plan has proved extremely successful where tried."—Jacksonville (Fla.) Times-Union.

SELECTED FORMULÆ.

Cold Creams.—

(1) Oil almond	26 ounces
Castor oil (odorless)	6 "
Lard (benzoated)	8 "
White wax	8 "
Rose water (in winter less, in summer more than quantity named)	12 "
Orange flower water	8 "
Oil rose	15 minims
Extract jasmine	6 drachms
Extract cassie	4 "
Borax	2 ounces
Glycerin	4 "

Melt the oil of sweet almond, wax, and lard together and stir in the castor oil; make a solution of the borax in the glycerin and rose and orange flower waters, add this solution, a little at a time, to the melted fat, stirring constantly to insure thorough incorporation; finally, add the oil of rose dissolved in the extracts and beat the ointment until cold.

(2) Oil almond	425·0 parts
Lanolin, anhydrous	185·0 "
White wax	62·0 "
Spermaceti	62·0 "
Borax	4·5 "
Rose water	300·0 "

Melt together the first four ingredients, then incorporate the solution of borax in the rose water.

An equally good preparation is obtained by melting together 30 parts of anhydrous lanolin and 60 parts benzoinated lard, and adding 100 parts of rose water.

Poultry Formulas.—The remedies for "chicken cholera" are almost as numerous as they are for curing a balky horse, and are of the most varied description. The United States Department of Agriculture pins its faith on alum water alone, and recommends giving each fowl four or five teaspoonfuls daily of "strong alum water," leaving the reader to use his discretion as regards the significance of "strong." The alum water is to be rubbed up with the food of the fowl. A well known English formula for a chicken cholera powder, which is based on the antiseptic property of iron sulphate, is as follows:

Iron sulphate	1 part
Calcium phosphate	8 "
Fenugreek	3 "
Capsicum	1 "
Alum	1 "
Wheat bran	2 "

Powder and mix, working up thoroughly. Put into paraffin cartons. On the label, as directions, put: "Dose, from three to four teaspoonfuls for each dozen fowls; to be mixed with the food. Sick and drooping chickens should be fed by hand. Keep dry."

The action of this powder is excellent, and it is enhanced by the addition to the food, along with the powder, of a small amount of onion chopped fine. To accompany the package there might be a little folder, giving general directions as to the management of a flock of fowls into which the cholera has come—the use of disinfectants, isolation of the sick, etc.

ROUP OR PIP REMEDY.

This is also, originally, an English preparation, and is intended to cure the fowl without the barbarous resort to removing the indurated end of the tongue:

Potassium chlorate	5 parts
Boric acid	5 "
Anise seed	10 "
White mustard seed	20 "
Millet	q. s. ad 100

Powder separately (remember the chlorate especially) and mix thoroughly. Put into paraffined cartons. Label: "Dose, for one dozen chickens, a level teaspoonful, mixed with the food."

"HEN PERSUADER."

Under this name, with an alias of "hen fruit stimulator," a poultry journal brought out the following some years ago, giving the formula a strong indorsement:

Iron sulphate	1 part
Red pepper pods	1 "
Black pepper	2 "
Lime phosphate	8 "
Bread crust or crackers	8 "
Fenugreek	4 "

Powder the ingredients and add four parts of clean white sand. If preferred, well boiled white beans may be used instead of the bread crust. The beans should be pressed through a colander to remove the hull, and then worked up with the powders. Label as follows: "For every dozen hens, add one level tablespoonful of the powder to the ordinary food, mixing it thoroughly, so that it may be as evenly distributed as possible."

The same journal recommends giving the hens, once or twice a week, lean beef finely minced with a little red pepper or Cayenne in powder, and powdered eggshells, dry bone dust, which substances, by the way, may be used instead of lime phosphate by taking double the quantity.—National Druggist.

Application for Mange in Dogs.—

Soft soap	4 parts
B-naphthol	1 "
Storax	2 "
Tobacco extract	3 "

To be applied to one-third of the skin at the most for three consecutive days. After three applications wash the whole body with dilute seabinol (a tablespoonful to a quart of water).—Veterinary Record.

A Good Mucilage for Paper on Glass.—Under this name, "vegetable glue," several years ago, a preparation was put on the market for which it was claimed that it was "ten times as strong as ordinary mucilage." Examination disclosed the fact that it was simply mucilage of gum arabic to which had been added about one per cent. of aluminum sulphate. The latter substance seems to have the property of greatly increasing the adhesive properties of the gum. To make a mucilage of this description dissolve 2 to 3 parts of aluminum sulphate in 20 parts of water, and add it to 230 parts of mucilage.—National Druggist.

PHYSICS WITHOUT APPARATUS—THE DICE AND BOX.

HOLD in the hand a box and two dice in the manner indicated in the illustration. Try to throw the first die up into the air and to catch it in the dice-box—not a very difficult feat. But the real difficulty is encountered in trying to catch the second die, for in throwing this second die into the air, the first, which is already in the box, is cast out. In order to succeed in catching the second die when the first is in the box, the second die should not be thrown into the air, but, by a quick movement, the box should be suddenly lowered, releasing the second die, so that the first, which is in the box, shall be lower than second, which is in the fingers. The two dice fall less rapidly than the hand and box.—From La Physique sans Appareils, La Chimie sans Laboratoire, by Gaston Tissandier.

A REGISTERING SOLAR RADIOMETER AND SUNSHINE RECORDER.

By GEORGE S. ISHAM, A.M., M.D.

THE object sought in making the machine about to be described was to get some simple form of registering apparatus which would give values in different places that could be compared, for that part of the total insolation of any place which goes to make it a source of convection currents, or what might be called the convectional potential of the place. To get absolute values for this seems an almost impossible thing to do, but if by any means reliable relative values can be obtained, they will for many purposes be quite as valuable in studying the many problems of local winds, thunderstorms, etc.

The black bulb is intended to represent any clod of earth or average matter exposed to the direct rays of the sun, and to all the winds that blow; the ordinary vacuum case is left off, as introducing far greater errors than it corrects. The shelter fulfills the above conditions as nearly as I can make it; a typical exposure would be an entirely unprotected one close to the ground. The position should be one that represents, as nearly as possible, the average of the locality.

The name solar radiometer is unsatisfactory, as it conveys the idea of a good deal more, and also something less, than is intended. Perhaps convectometer would be better. Its uses as a sunshine recorder and as a means of measuring the heat given to vegetation are self-evident. For the latter use it would be better to color the tube green or treat it as De Blanchis has done in his investigations.

The machine has been given its present form as presenting a curve which requires the simplest corrections, there being no correction for pressure, specific gravity, or temperature. It is also simple enough to be understood and successfully run by persons not specially trained. The instrument, in part like the registering barograph of Sprung, is made as follows: A long, straight scale beam, *C*, is balanced in the middle on a knife edge, resting on the support, *A*. Each end of the beam supports on its upper side a perpendicular glass tube hung by a collar, *D*, fitted with knife edge bearings, the collar being fastened a little above the middle point of the tube. These tubes dip into cups, *S*, *S*1, connected together by a tube and capable of being raised or lowered by the screws, *T*, *T*1. One of these tubes is covered with lampblack above the collar.

Suspended from the beam by a rigid rod, with a screw thread on it, is the weight, *Q*, by moving which balance may be had in adjusting, and position of c. g. of the balance changed by changing its weight. On the beam next the blackened tube is a track on which runs the carriage, *E*. This carriage is attached by the wire method, or by two universal motions, to the arm, *F*, which, in turn, is fastened to the nut, *G*. The arm motion is limited to a right line parallel to the track by a rod which runs through a hole in the arm.

The nut, *G*, which also carries the pen, is moved backward and forward by the screw, *H*, geared to the perpendicular shaft, *I*, which is broken by the universal motion, *J*. The lower end of the shaft passes through a square block of soft iron, which block is limited by guides to a to-and-fro motion between the magnets, *K*, *K*1; it then terminates in a gear wheel which engages either one of the wheels *L*, *L*1, according to which magnet is excited. A clockwork motor, *M*, run by a weight and governed by a flywheel, turns the shaft on which are the two gear wheels, *L*, *L*1, always in the same direction. This motor is started or stopped by the magnet, *N*, the armature of which moves a check to the flywheel.

From the back of the beam, in the middle, is a long pointer, terminating in platinum contacts (shown at the end of the beam in the drawing to avoid confusion). One or the other of these contacts, on the slightest motion of the beam, touches the point, *R* or *R*1. The contact, *R*, is connected with the magnet, *K*, and the battery and the contact, *R*1, with the magnet, *K*1, and the battery. The other pole of the battery runs through the magnet, *N*, and to the plate, *B*, on which the knife edge of the beam rests; the plate and the

PHYSICS WITHOUT APPARATUS—THE DICE AND DICE-BOX.

arm, *F*, being insulated, only the scale beam is in circuit.

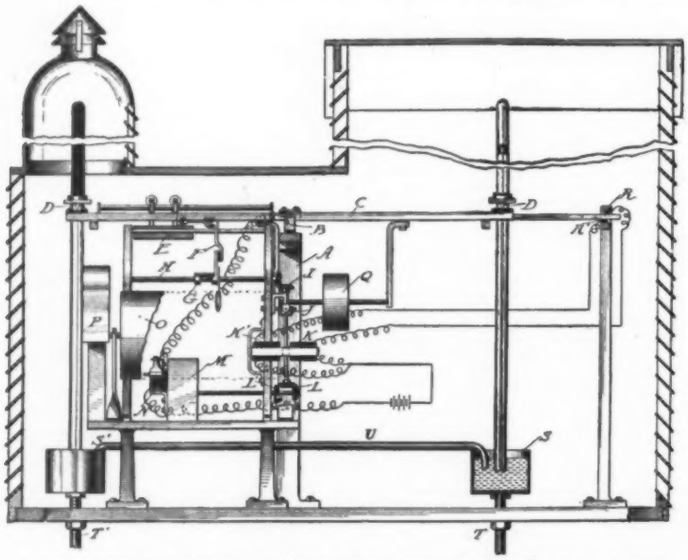
The tubes are filled with pure mercury and set in place in the same manner and with the same precautions as in filling a barometer tube, a liberal amount of mercury being left in the cups; the connecting tube is filled and put in place; then enough absolute alcohol is injected into each tube to insure, under all conditions of temperature and pressure, a saturated vapor of alcohol at the top.

An addition is built to the south side of an ordinary weather bureau shelter for thermometers, having a flat top and the same louver board sides; over a large hole in the top is put a glass cover; one-third of its circumference on the north is cut out and louver boards put in; on north side of the middle of the top of cover (not in middle as shown in cut) some form of lantern top is put. The ventilation must be as free as possible.

When the sun is not shining, both tubes are of the same temperature and the tension of the alcohol vapor is the same in each; both tubes weigh the same, and the machine is in equilibrium. This will be true whatever changes there may be in the temperature of the air or the atmospheric pressure.

If the sun, or any source of heat, act upon the black tube, the tension is increased, some mercury is forced out of the tube, the weight becomes less, contact is made at *R*1, the magnet, *K*1, engages the wheel, *L*1, the motor is started and the carriage is moved out upon the beam until the balance is restored, when contact is broken and the motor stopped.

When the source of heat is removed the tube cools, tension is decreased, amount of mercury is increased, equilibrium is disturbed, contact at *R* is made, and motion of carriage reversed and continued until equilibrium is again restored.



A REGISTERING SOLAR RADIOMETER AND SUNSHINE RECORDER.

Secured to the nut, *G*, is a pen which moves with the nut parallel to the axis of a cylinder, *O*, rotated once in twenty-four hours by the clock, *P*.

The following dimensions for parts give good results; tubes ¾ inch inside diameter, 32·5 inches long; scale beam, 30 inches.

The vapor chamber should be as small as possible; so the cups are arranged to be lowered or raised by screws in order to just accommodate, and no more, the largest probable change in temperature and pressure for the season, and to adjust for elevation above sea level. Because, as the tension of saturated vapor in any chamber is the tension of the coolest part, so the smaller the chamber, the more sensitive it will be. The circumference of the cylinder, *O*, is 48 centimeters, which makes one millimeter equal three minutes of time. A difference of one millimeter in tension, by adjustment of the weight of carriage, causes a motion of two millimeters in the pen.

These dimensions seem to be large enough to nearly exclude mechanical errors and not too large for convenience. If more accurate values as regards time are required, the motor should be arranged for two different speeds by having, for example, the first contact of the pointer made through a light spring, which starts the motor as above, but upon increase of weight it closes a second circuit which would raise a brake or friction wheel from the motor, thereby increasing the speed.

A motor that moves at a constant speed is either so slow that the pen falls behind a sudden change in temperature or so fast that it causes oscillation on slight changes.

The use of a saturated vapor in this way I believe to be original. I have chosen ethyl alcohol as giving the best average results, though experience may prove that the use of ether in winter and alcohol in summer, or some such combination, may be better.

The difference in vapor pressure in millimeters of mercury of ethyl alcohol between 0° C. and 5° C. is about 5 mm. and lower down the difference is very much less, which would probably give inaccurate results.

To reduce the tracing on card there must be either a synchronous tracing, preferably on the same card, by a thermograph, or observations of a thermometer; for the curve represents the difference in temperature between a shaded and a black bulb thermometer.

The pen, when the sun is not shining, draws a straight line around the card which is the base line of measurement, but must have a different value for different temperatures. Suppose that at twelve o'clock noon on a certain day the curve measured 38·4 mm. from the base, and at the same time a sheltered thermometer or the thermograph trace showed a temperature of 25° C.; then, as tension of alcohol vapor at 25° C. is 58·86 mm., adding half of the 38·4 (for the machine multiplies by two) the sum equals 78·06 mm., equals tension at 30° C., equals temperature of black bulb thermometer at that time. This may be done by simple inspection by making a transparent scale as follows:

Take a strip of glass or transparent celluloid, lay off from a base line which is marked 0° C. 10·14 mm., and make another mark and number it 5° C.; for this distance is double the number of difference in millimeters of mercury of pressure of alcohol vapor, between 0° and 5° C., and so on all the way up and down the scale from the zero, taking the numbers from tables and interpolating by graphic method, values for degrees not given. Having made the scale, lay it on the card and put for every reading you wish to make the number representing the degrees temperature shown by the thermometer for that hour over the base line; then where the curve crosses the scale is the temperature of the black bulb at that time.

In order to compare the values of the reading for the same day at different places, I would suggest the following: The paper I have used is ruled in square millimeters and centimeters. It can be bought in any of the shops and serves the purpose; all that is necessary is to cut it in strips of the requisite width and mark a few of the hours on the transverse lines.

When reading the actual temperature by the scale for every half hour, hour, or two hours, according to the accuracy desired, make a mark on the hour line at the intersection of the millimeter line corresponding to the number of degrees of difference between the shaded and black thermometer; e. g., if the difference is 12°, make a dot at the intersection of the twelfth millimeter line (measured from the base) with the hour line being measured. When they are all measured, join all these dots, and the area of the surface included between the base and the irregular line so made is the measure of the local insolation.

The thermograph should be arranged to trace its curve on the other side of the base line, one millimeter for each degree, or the curve may be plotted; then the area of the surface included between the two irregular curves so made is computed by inspection or by a planimeter; the number representing this area is purely arbitrary, but gives a good method of comparing any number of cards of the same or different places.

I think there are no corrections to be made for instrumental errors, other than mechanical ones, which is the advantage in using a saturated vapor, except in case of sudden change of temperature, when, though the machine acts almost instantaneously, it is slower than the actual change, but compares very favorably in rapidity with ordinary thermometers, either mercurial or alcoholic.

The many ways of varying the machine will be evident upon a little reflection. The form as shown is simply the one that seems to me to be best; a better way of exposing it might alter its form greatly and simplify it, but I do not know of one which will protect it from wind and rain.—American Journal of Science.

The will of Sir Henry Bessemer, just probated in London, fixes the gross value of his estate at only $462,690, of which the net value of the personal estate was $291,085. But the will appears to indicate that he had given away during his lifetime property valued at two or three times as much as the above gross amount. His property is divided between his wife, two surviving sons—Henry and Albert George—and his daughter, Mrs. Elizabeth Wright, and her husband. He also provides for the family of Mr. Alfred George Bessemer, and leaves small legacies to servants and several specific bequests to some of the institutions of which he was a member.

NATURAL HISTORY OF THE LOCUST.

THE family Acrydii of orthopterous insects contains numerous genera and species, some of which move in swarms so great as to darken the sky, and the voracity of which is so insatiate that the places at which they alight at once become destitute of a green leaf or a blade of grass. The natural history of these insects, popularly called "locusts," has recently been written by M. Fabre, of Avignon, and from a synopsis

FIG. 1.—ARRANGEMENT FOR REINFORCING THE SOUND MADE BY THE LOCUST.

of his work, made by La Nature, we take the following particulars.

Locusts, many of which produce a disagreeable stridulating noise, live in the ground in the larval state for nearly four years, in the case of the European species studied by M. Fabre.

They move about in the earth and feed upon the juice of roots, which they suck therefrom by means of their proboscis. At the end of the four years they seek very dry ground exposed to the sun, wherein they excavate vertical galleries sixteen inches in length, terminating at the bottom in a small chamber in which they live most of the time. The rest of the gallery is a sort of meteorological observatory which they ascend in order to see whether the heat is sufficient to permit of their exodus. What is remarkable is that, although the walls of the gallery are lined with a coat of plaster, no rejected earth is to be observed externally. What, then, has become of that which filled the cavity? Fabre remarks that the larva emits from its posterior extremity an abundance of a liquid which, for want of knowledge as to its character, he styles, provisionally, urine.

According to him, this liquid, mixed with vegetable mould, permits the latter to penetrate the interstices of the coarse earth. The thinner portion first infiltrers and the rest becomes compressed and compacted in occupying the vacant intervals.

After it has made its exit from the ground, the larva crawls up a branch and fixes itself thereto very firmly (Fig. 3).

The back of the imprisoned insect soon splits the external shell, and its head, legs, and wings then make their exit. In order to facilitate this operation, the locust turns itself backward, at first horizontally and then vertically, the abdomen always inclosed in its case. After the front part has been disengaged, the insect rises, and, fixing itself with its legs, permits the abdomen to make its exit. Finally, the insect becomes free, but is in a soft state and incapable of flight. Half an hour's exposure to the sun suffices to harden the wings, and the locust then flies off and lights upon a tree, from which, always turned toward the sun, it sucks the sap with its proboscis. When it is annoyed, it directs a jet of liquid at its disturber. The French peasants well know this peculiarity, and even think that there is nothing better as a cure for renal infirmities than a ptisan of locusts. As for locust larvæ, so highly appreciated by the Greeks as food, M. Fabre asserts that they are almost inedible, despite their nutty taste, on account of their coriaceous character.

The musical apparatus of the locust has already been described by Reaumur and Carlet; but we think that it will be well to revert to the matter, because the description has been somewhat "popularized." Fabre's description, which we give nearly in extenso, is remarkably clear. The male alone produces a sound. Beneath its abdomen, immediately back of the hind legs, there are two ample semicircular plates that slightly overlap, that to the right over the one to the left (Fig. 2). These are the opercula of the sound-producing apparatus. Then two spacious cavities, known in Provence by the name of "chapels," open, one of them to the right and the other to the left. Together they form the "church." They are limited in front by a fine and soft cream colored membrane, and behind by a dry pellicle, as iridescent as a soap bubble, called the "mirror" in Provence. The "church," the "mirrors," and the covers are popularly considered as the sound-producing organs. But this is a mistake, for we may break the mirrors, remove the opercula with a pair of scissors, and lacerate the anterior membrane without thereby putting an end to the locust's noise. Such mutilations simply alter and slightly reduce the sound. The "chapels" are organs of resonance. They do not produce the sound, but reinforce it through the vibrations of their anterior and posterior membranes, and modify it through more or less open shutters.

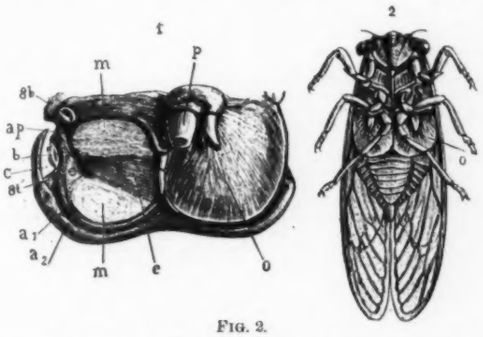


FIG. 2.

1. Musical Apparatus of the Locust seen by the Ventral Face. The front part of the right shutter has been cut off at the base. a^1, the first ring of the abdomen; a^2, second ring; ap, apophysis of the folded membrane; *C*, cavern; *e*, wing of the entogaster; *m*, mirror; m^1, folded membrane; *P*, leg of the third pair; *8t*, *8t'*, stigmata; *t*, timbal; *0*, shutter. 2. Locust seen by the Ventral Face, and Showing the Musical Apparatus, *0*.

The true sonorous organ is quite difficult for a novice to find. Upon the external side of each chapel, at the junction edge of the back and abdomen, there is a fissure which is limited by coriaceous walls and concealed by the overhanging operculum. Let us call it the "window." This aperture gives access to a sonorous chamber deeper than but not so spacious as the contiguous chapel. Immediately back of the point of attachment of the hind wings there is observed a slight, nearly oval, protuberance, which, through its dull black color, is distinguished from the neighboring integuments covered with a silvery down. Upon making an opening in this, we lay bare the cymbal, the organ that produces the sound. This consists of a small, dry, white membrane of elliptical shape, which is convex externally and traversed from one extremity to the other by a bundle of three or four brown nerves, which give it a spring, and which is fixed by its entire circumference in a stiff frame. If this shell be depressed and then allowed quickly to resume its former convexity through the action of its elastic nerves, there will result a clicking sound like that produced by the toy called the cricket. The convexity of the cymbals is produced by the contraction of two muscular pillars associated in the form of a V.

Nothing is easier than to cause a dead but still flexible locust to make the noise peculiar to it. It is only necessary, with a pair of pincers, to grasp one of the muscular columns and give it a few gentle pulls in order to make the cymbal emit the stridulating sound. The latter will be faint, it is true, and devoid of that amplitude that the living insect attains by means of its chamber of resonance; but the fundamental element of the noise is, nevertheless, obtained through this artifice of the anatomist. If, on the contrary, it be desired to render a living locust mute, it is useless to do violence to the chapels or to break the mirrors, since no such mutilation will moderate the noise. But if, through the lateral fissure that we have styled the window, we introduce a pin and prick the cymbal, the latter will immediately be rendered silent. A slight prick produces an effect that would not be obtained by eviscerating the insect.

The opercula, which are rigid plates firmly held in frames, are immovable. It is the abdomen itself that, ascending or descending, causes the church to open or close. When the abdomen descends, the opercula accurately close the chapels as well as the windows of the sonorous chambers. The sound is then reduced, deadened, or smothered. When the abdomen ascends, the chapel opens, the windows are free and the sound acquires its full volume. The rapid oscillations of the abdomen, which are synchronous with the contractions of the motive muscles of the cymbals, therefore determine the variable amplitude of the sound, which seems as if it were due to the quick movements of a violin bow.

The description that we have just given relates to the common locust. In France there are other species, one of the most frequent of which is the elm locust, which on account of its song, so to speak, is called the "cacan." In this, the sonorous chamber, and, consequently, the window, is wanting. Moreover, from the front of the first segment of the abdomen starts a short and wide rigid tongue which rests upon the cymbal

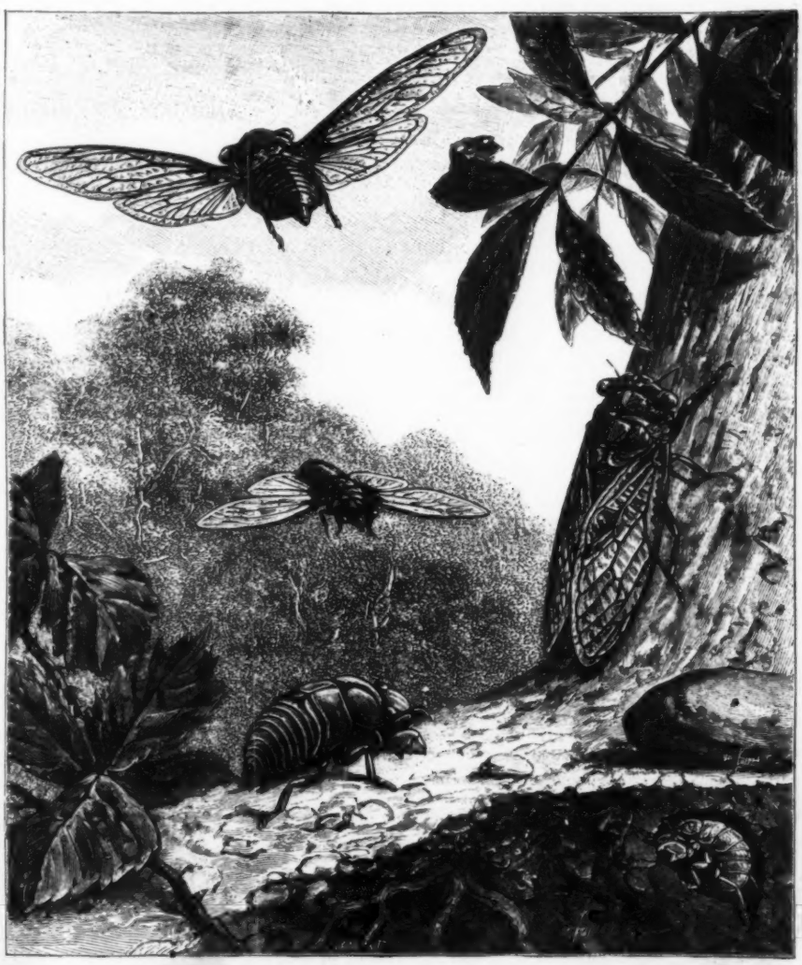


FIG. 3.—THE COMMON LOCUST IN FLIGHT AND AT REST.

Beneath, the larvæ are seen upon the surface of the ground and in the act of making their exit from the earth.

through its free extremity. The chapels, like the mirrors, are very small. The apparatus of resonance here consists of the abdomen, which is occupied by a cavity so ample that its entire circumference is translucent. It is nevertheless through this slight thickness that passes the digestive tube, which is reduced to a thread. This hollow abdomen and its thoracic complement form, says Fabre, a huge resonator, such as is possessed by no other locust of our regions. If the extremity of the abdomen be cut off and a finger be placed over the aperture, the sound will become graver, conformably to the laws of sonorous pipes. If to the aperture there be adapted a cylinder or a paper cornet, the sound will gain in intensity as well as in gravity. With a cornet properly arranged and the wide end inserted in a reinforcing test glass (Fig. 1), it will no longer be the sound of the locust that is heard, but almost the bellowing of a bull.

Why do locusts make so loud a noise? It is usually said that it is for the purpose of attracting the females and charming them. Fabre very appositely remarks that the males and females remain alongside of each other on the branches, occupied or not in sucking the sap, but in any event not animated by that febrile movement that is exhibited in the majority of animals at the moment of reproduction.

Moreover, no female is observed to run toward the musician in order to throw herself into his arms as it were. When the male desires to perpetuate his species he takes the first female that he meets with, without even asking her consent.

On another hand, it is almost a general rule in zoology that animals which sing in view of the union of the sexes have acute hearing. Now, from the experiments of M. Fabre it results that the locust is deaf or nearly so. "Of my experiments in this line," says he, "I shall mention but one, the most memorable. I borrowed the municipal artillery, that is to say, the guns that are fired on dedication day. The gunner took pleasure in loading them, on account of the locusts, and in coming to fire them at my house. There were two of them, both heavily loaded, as if for public rejoicing. Never was a politician making a tour through an election district honored with so much powder. In order to prevent the breakage of glass, the windows were opened. The two guns were arranged at the foot of the plane trees in front of my door without any precaution being taken to mask them. The locusts singing away on the branches above could not see what was going on beneath. There were six auditors of us. A moment of relative calmness was awaited. The number of the musicians was noted by us, as was the rhythm and amplitude of the sound. All being ready, and every ear on the alert as to what was to take place in the aerial orchestra, one of the guns was fired with a deafening noise; but there was no commotion up above. The number of the performers was the same, as was also the rhythm and amplitude of the sound. The six witnesses were unanimous in the opinion that the powerful explosion had in no wise modified the noise made by the locusts. With the second gun the result was identical." Under such circumstances, it will be seen that it would be useless for the males to make music for fifty or sixty days in order to charm the females.

Locusts deposit their eggs in the interior of dry branches, which they perforate to this effect with their ovipositor. In summer, when the sun is very hot, the young locusts make their exit from the egg and bury themselves in the earth, and after this their history is not very well known.

TREATMENT OF THE SURFACE OF MEDALS.*

SILVER.

In this country medals have been issued for centuries with the tables or flat surfaces smooth and mirror-like, while a more or less frosted texture has been given to the portions in relief. This is especially the case in medals which have been struck as specimen pieces, for after highly polished dies have been used for a certain time the difference between the appearance of the tables and the parts in relief becomes less and less marked. As is well known, medals with polished surfaces rapidly tarnish, and even blacken, by exposure to the ordinary atmospheric influences. In France a different system has long been adopted concurrently with the one just described. Unpolished dies are employed, and care is taken to impart to the medals struck from them a dead or frosted surface by rubbing them with fine pumice.

Recently, at the French mint, medals have been subjected to the process known as "sand blasting" by the aid of an appliance which projects against the surface of the medal a small jet of air, carrying with it fine sand, and having a velocity of about 180 feet per second. When thus treated the surface of the medal becomes minutely granular or frosted, and may then be further treated in several ways. Sometimes the surface is darkened by exposure to an aqueous solution of a sulphide, followed by rubbing with very fine pumice, which removes the dark layer of sulphide from the portions in high relief and leaves dark lines in the more deeply cut recesses. It is, however, preferable to cover the medal with a layer of platinum, and this is effected by immersing it in an alcoholic solution of chloride of platinum until a blackened surface is produced. Subsequent rubbing with a brush and very fine pumice changes the blackened surface to a delicate gray; and if this operation is conducted skillfully, graduated shadows may be left wherever the artist considers their presence to be desirable. The beauty of medals so treated, and the fidelity with which the details of the design are revealed, are beyond question; but it may be doubted whether the surface of the medal is permanently protected. A medal with a frosted platinized surface has, however, a great advantage over one with a polished table, as the platinized medal is merely deepened in tone by exposure to the atmosphere, and, unlike medals which have been struck in the ordinary way, does not become disfigured by blotches of tarnish. The frosted platinized medal may be restored to almost its original freshness by careful rubbing with a soft leather; while a polished silver one cannot be so renovated, as the tarnish attacks the surface and destroys the polish.

During the past year, for the first time in the history of the mint, medals have been issued with frosted and platinized surfaces. More than 27,000 large silver medals were platinized by a slight modification of the above method. It became necessary, therefore, to provide an appliance for producing the sand blast, and this, together with a small one horse power motor for driving it, has been fitted up in the basement of the Assay Department.

BRONZE.

Medals of bronze differ considerably from those of silver, as their surfaces are far more liable to be influenced either by the slow operation of the constituents of the atmosphere or by the more rapid action of chemical agents. Ancient silver coins, for instance, which have been long buried in the earth, do not show anything like so wide a range of color in their patina or crust as is revealed on coins of brass, bronze, or copper, which have been hidden in the same way. This is due to the fact that silver is far less affected than copper by the chemical action of the constituents of soils or by atmospheric influences. The patina acquired by an ancient coin or medal often constitutes no small part of its value.

"You would laugh at me," said Philander, in Addison's charming dialogues upon the usefulness of ancient medals, "should I make you a learned dissertation on the nature of rusts; I shall only tell you that there are two or three sorts of them which are extremely beautiful in the eye of the antiquary, and preserve a coin better than the best artificial varnish." The object of the medalist is accurately expressed in the above sentence, for he endeavors to protect the surface of all medals in which copper is the main constituent by a patina or film of oxide, so as to preserve the medal from further change. This may be effected in various ways. The medals of the Italian Renaissance were not struck, but cast by the method of cera perduta, already described in these reports,* and much of the beauty of the medal was due to the "skin" or pellicle of oxide which the medal acquired during casting. The skill of the artist in arranging the composition of the bronze, and fixing the temperature at which it was cast, was revealed in the texture of the medal's surface.

In modern times most medals to which the name of bronze is given are really of copper, "bronzed" or colored artificially on the surface. The process by which this coloring is effected has long been employed, and is thus described in an old receipt. Apply with a brush to the surface of the medal common crocus powder, jeweler's rouge, previously made into a smooth paste with water. When dry, expose the medal over a clear fire for about one minute; lastly, when the medal is sufficiently cold, polish it with a plate brush. The exact composition of the superficial layer of oxide which is formed has, I believe, never been ascertained; but it is well known that the tint varies greatly from light brown to deep chocolate, according to the particular variety of oxide of iron which is used.

With a view to ascertain whether this old method could not be replaced with advantage, it was natural to turn to the work of Japanese artists, who are masters in the art of giving protective surfaces of varied tints either to copper in its pure state or to copper alloys. I have shown elsewhere† that in conducting such operations the Japanese employ dilute boiling solutions of certain salts of which verdigris and sulphate of copper are the more important.

The following solution‡ has been found to answer fairly well, even when the ordinary European verdigris, which is a basic acetate of copper, is employed:

Verdigris	87 grains.
Sulphate of copper	437 "
Niter	87 "
Common salt	68 "
Sulphur	233 "
Water	1 gallon.

In Japan, however, "verdigris" is made by the action of plum-juice vinegar on plates of copper which contain certain metallic impurities. Such native verdigris has consequently a very complex constitution. It is called "Rokusho," and cannot be procured in this country; but I am indebted for a sample of it to Mr. W. Gowland, formerly technical adviser to the Japanese mint at Osaka. He obtained it from a famous maker of verdigris at Osaka, who presistently refused to give any information respecting its mode of manufacture. Mr. Gowland also gave me an elaborate description of the method of employing this verdigris in the coloring of copper medals, a method which has only been adopted in Japan as the result of a long series of experiments. Guided by an analysis which was made of this "Rokusho," a mixture was compounded which produced quite as fine patina on copper as the native "Rokusho," though its action was less certain and less rapid. The series of tints which may be obtained by slight variations in the composition of the "Rokusho" is truly remarkable. These tints range from golden yellow through deep brown to bright red, the color mainly depending on the relative amounts of malate, urate, and chloride of sodium which are present.

The quality of the copper also exerts a very great influence on the tint of the patina; the difference, for instance, between ordinary "best select" copper of the smelter and "electro" copper is very marked, as the former becomes dark brown and the latter golden yellow when boiled in the same solution of "Rokusho." Since the close of the year 1897, over 5,000 medals have been treated by the method which has just been described. Apart from the mere tint of the medal, the Japanese artists attach much importance to producing a sheen or damascening which shows through a transparent patina. This is effected by developing the crystalline texture of the copper by a preliminary treatment of the medal before it is boiled in the solution of "Rokusho."

In France, medals of true bronze containing much zinc are struck, and although the color is heightened by superficial oxidation, produced by gentle heating, no true patination is effected.

PHOTOGRAPHIC SURVEYING.

Fifty years ago or more, M. Beautemps Beaupré successfully employed a process which greatly facilitated the work of surveying, and which in its modern developments is likely to supersede the tedious work of measurement in the field. Where the greatest accuracy was not required, the method recommended itself on account of its great practical utility, enabling contoured maps to be produced without the labor of heavy calculations. M. Beaupré availed himself of the principle of the camera lucida, and by its aid sketched the panorama about him from two ends of a measured base line. In a paper recently communicated by Prof. E. J. Mills to the Institution of Engineers and Shipbuilders, in Scotland, it is contended that the best work is still done when this principle is utilized. From two views taken at a known distance from each other, however procured, one is able to plot a map with a fair amount of accuracy, and knowing the correct relative distances of the objects their vertical height can be deduced. No doubt there were difficulties in the application of the method. Any one who has attempted to draw a picture of a distant object by means of Wollaston's invention knows that the result is apt to be a little disappointing, though successive improvements in the mechanism have removed many of the effects arising from parallax, which interfered with correct delineation in the early days when the instrument was first used. But the process still remains long and tedious, and it was inevitable that the introduction of photography, with its rapid and accurate results, should be welcomed as likely to banish the slow methods of hand drawing in the initial stages of the work.

To obtain a photograph which should be free from optical distortion, and to which the laws of geometrical perspective could be applied without any correction, has not been an easy task. But now it may be said that we do possess lenses which will cover an angular field of about 60° without measurable distortion, and give uniform definition all over the plate. Enlargements and printing from the original negatives doubtless still present some difficulties. Prof. Mills, we notice, recommends that the prints should be made on bromide paper, and developed with amidol. Shrinkage and distortion of the paper will, it is asserted, be prevented, when soaked in a two per cent. solution of formalin, and dried at a gentle heat. Other authorities, however, distrust paper altogether, and prefer to use a bromide emulsion on opaque or translucent plates of flat glass as likely to give less error. But the possession of accurate optical arrangements, combined with exact manipulation of the photographic result, suggests many new applications to which the camera can be profitably applied, and the surveyor now finds himself equipped with an instrument of scientific precision, in which are combined the main features of a theodolite and a level, and which replaces the plane table and its accessories.

In the earliest form of surveying camera or photogrammeter, to give it a polysyllabic title, the instrument consisted of little more than an ordinary bellows camera, set on a horizontal circle, and moving about a vertical axis. The distance between the plate and the lens was fixed, and the camera could be leveled by means of screws in the head of a tripod in much the same way that a theodolite is adjusted. In the subsequent development and increased effectiveness that have been added to this surveying instrument, two names stand out prominently, that of Colonel Laussedat, the present director of the Conservatoire des Arts et Metiers, Paris; and in this country that of Mr. Bridges-Lee. In the French form, the camera is placed on the top of a stand carrying a transit theodolite, and the disposition of the several parts is arranged to ensure stability and symmetry about a vertical axis, while each part of the instrument can be used separately. In the English form, Mr. Bridges-Lee has wisely determined that while each photograph should offer a correct perspective view of the country it represents, it should also carry on its face the information necessary for the correct interpretation of the picture, and the subsequent construction of a map. When passing through countries where roads are scarce and traveling difficult, notebooks are apt to be lost; but without more words, everyone must appreciate the arrangement by which the "constants of reduction" are made as permanent as the picture to which they refer.

The general principles on which the Bridges-Lee camera has been constructed, and the objects sought to be attained, have already been briefly explained in these columns (Supplement 1078). Its present form has been adopted because experiment has proved the necessity of great nicety of mechanical adjustment to obtain the best results. To ensure the necessary lightness and rigidity, the camera box is made of aluminum. The direction in which the instrument is pointed can be read off an azimuthal circle, graduated to minutes, on which the camera turns. A level on the top of the box ensures the horizontality of the instrument, and when this adjustment has been made, a telescope, also securely attached to the top of the camera, will move in a vertical plane through a sufficient range of angle for all ordinary terrestrial work. The angle through which the telescope can be moved in altitude is also read to minutes. This supplies the observer with a theodolite, and its position is so arranged with reference to the other parts of the instrument, that the line of collimation and the vertical wire of the theodolite are in the same plane with that which bisects the photographic lens. In this same vertical plane, a "wire" is fixed to the frame of the camera, cutting the optic axis of the lens at right angles, and consequently marks on the photograph the median vertical plane of the instrument. Another wire, also through the optic axis at right angles to this, will mark the horizon of the instrument on the picture, and the intersection of the two wires will give the "principal point" of the perspective. Inside the camera is placed a magnetic compass, and the scale being transparent, it is printed on the picture. The axis of rotation of this compass is in the same plane as the axis of colli-

* From a memorandum by Prof. Roberts-Austen, C.B., F.R.S., in the Twenty-eighth Annual Report of the Deputy Master and Comptroller of the Mint, 1897, and published in Nature.

* Sixteenth Report (1886), pp. 24, 49; Seventeenth Report (1886), p. 15.

† A paper "On the Use of Alloys in Art Metal-work."—Journal of the Society of Arts, June 13, 1890.

‡ A similar solution for heightening the color of gilded metals is described by Benvenuto Cellini in his "Trattato dell' Oreficeria in Florenza, 1568."

mation of the theodolite, and of the vertical wire. The distance between the scale of the compass and the vertical wire is kept constant by a device which works automatically when the camera is in use, and since this distance very slightly exceeds the radius of the compass, the wire can be used as a pointer to read the scale. One very important addition to the usefulness of the instrument is the insertion of a scale of angular distance, photographically prepared by the same lens as that fitted in the instrument when complete for surveying purposes. The scale is so attached to the frame that it is photographed on every picture taken, and by its aid one can easily read off the angular distances of any point in the picture right or left of the median vertical plane.

A method of surveying in which the necessary observations are easily and rapidly collected, or are implicitly contained in a series of photographic views, has the promise of a large future. In traveling over unsettled districts, where it is impossible to remain for any length of time on a particular spot, the photographic method seems likely to supersede all others. Indeed, no other method seems possible. Moreover, a photograph contains an amount of detailed information concerning the country photographed which it is quite impossible to gather from notes of observation and sketches, although much time may be spent in making these additions as carefully as possible. In this connection, one might call attention to the beautiful mountain maps which have been prepared for the German and Austrian Alpine Club. Here the work is based on the original ordinance survey maps, and the topographical details filled in from photography. These maps represent one of the most successful applications of photographic surveying. Again, in preliminary experimental surveys for irrigation purposes, or for deciding on the best route for a proposed railway, the camera, properly controlled, possesses many advantages over ordinary surveying instruments. In such cases it is often excessively difficult to determine beforehand how much plotting will be necessary to secure the object in view. The district may have to be revisited over and over again to supply the requisite details, all of which may prove useless in the end. But with the photographic pictures secured by a camera, the plan may be plotted so far only as required, and if additional information be needed, the photographs can be made to give all the details wanted without going again to the field. Irrigation surveys for agricultural purposes have been effected in the North-West Provinces with complete success by the photographic method, and are likely to be still further extended. Prof. Mills tried to apply the method to the determination of the content of a ship in dock by constructing a model of the vessel in clay, the necessary dimensions for which were to be taken from measured photographs. When the amount of clay in the model and the scale of the photograph from which the necessary measurements have been taken are both known, the capacity of the ship is at once determined. In this particular instance, it is true, the method failed, owing to the impossibility of selecting suitable stations for the photographs amid the crowded machinery of a busy ship-building yard. But the attempt shows the wide applicability of the method and the extent of the field opened to the intelligent use of photographic appliances.

But its greatest triumphs are, of course, to be seen when the method is continuously applied over a large area. One of the most successful operators is Mr. E. Deville, the Surveyor General of Dominion Lands, who has carried his investigations over the difficult passes of the Rocky Mountains, and surveyed the country to the United States boundary of the Alaska territory. No less than 14,000 square miles of this inhospitable country were surveyed in the years 1893-94. The proper administration of the country, he tells us, required a tolerably accurate map, and means had to be found to execute it rapidly, and at a moderate cost. The ordinary methods of topographical surveying were too slow and expensive for the purpose; rapid surveys, based on triangulations and sketches, were tried and proved ineffectual; then photography was resorted to, with the result just mentioned. The same authority, as was natural to one in his official position, has made a very careful comparison of the relative expense of a survey made with the plane table and one with the camera; all such comparisons are liable to be modified by the climatic conditions of the country, and the amount of detailed plotting required. In the climate of the Rocky Mountains, Mr. Deville estimates that on one-half of the number of days in a season, no work can be done with a camera, owing to smoke, fog, rain and snow storms. But quite as great a loss of time is experienced with the plane table, added to which the apparatus is more weighty, requiring more porterage, and therefore additional expense in removal. But neglecting these and some other slight advantages which are on the side of photography, he finds that the plane table survey is three times (rigorously as 164:56) more expensive than that accomplished by the camera. This is a real practical advantage which is immediately appreciated, and on several grounds, not taken into Mr. Deville's estimate, such as the possibility of reducing the number of highly-trained assistants, it would seem that the difference of expenditure has not been over-estimated. There is no sacrifice of accuracy to secure this economy; the great improvement consists in the substitution of the methods of photography—methods which, proving highly popular, must tend to displace more and more the use of the plane table.—Nature.

A CLASSIC LEGACY OF AGRICULTURE.

By JOHN MILLS, in Knowledge.

THERE is no more beneficial creation of wealth than that which arises from the complete development of the resources of the soil and the correct manipulation of its products. Better education in agriculture would contribute largely to an intelligent appreciation of the problems which arise in farming as a business and increase the efficiency of the mental machinery destined to direct operations in the field. Farmers of the future, whose minds are thus counterpoised and adjusted so as to retain their equilibrium under all conditions—favorable and unfavorable—will play an important part in the struggle for supremacy between civilized countries; and, so equipped, complete confidence may be placed in the ability of the tillers of the soil in our own country to maintain a secure place in the markets with rivals, distant and near, who make it their chief occupation to supply our population with food. In the attainment of such knowledge a great multitude of facts present themselves for consideration, each of which requires due thought to discern its bearing on the whole and to assign it a place in agriculture so as to render the science of maximum usefulness. Thus, the quantity and quality of the crops, the character of the soil and of the climate, differences in the habits of plants, general economy of the farm, and so on, give rise to a number of questions which form a sort of algebraic equation involving many unknown quantities, and to solve which requires not only a vast amount of exact observation, but also profound skill in the marshaling of facts and manipulation of data.

The atmosphere is a subject which has engaged the attention of many inquirers, notably Sir John Lawes and Sir Henry Gilbert, at Rothamsted; and a theme of much controversy among scientific men for many years past has been, "How is the fixation of nitrogen to be explained?" Diversity of opinion still obtains on this question, and, unfortunately, there is yet much to learn before a satisfactory answer can be given; but though the explanation is wanting, there can be no doubt that the fact of the fixation of free nitrogen in the growth of leguminosæ—clover, vetches, peas, beans, sainfoin, lucerne, and so on—under the influence of suitable microbe infection of the soil and of the resulting nodule formation on the roots, may be considered as fully established.

What, then, is the basis of this conclusion? Recent experiments at Rothamsted show that, by adding to a sterilized sandy soil growing leguminous plants a small quantity of the watery extract of a soil containing the appropriate organisms, a marked development of the so-called leguminous nodules on the roots is induced; and that there is, coincidently, increased growth and gain of nitrogen. For example, in growing peas, there was limited growth in pot 1 (see figure) with sand without soil extract, and also an entire absence of nodule formation on the roots. The increased growth in pots

PEAS GROWN IN EXPERIMENTS ON THE FIXATION OF FREE NITROGEN.

2 and 3, with soil extract, was coincident with a very great development of nodules. In pot 4, with garden soil, itself supplying abundance of combined nitrogen and doubtless micro-organisms as well, there was also a considerable development of nodules, but distinctly less than in either pot 2 or pot 3 with sand and soil extract only. Further, without soil extract and without nodules there was no gain of nitrogen, but with soil extract and with nodule formation there was much gain of nitrogen. Experimental results, in fact, clearly prove that there is immense gain of nitrogen under some conditions. It has also been conclusively shown that due infection of the soil and of the plant is an essential to success. The available evidence at the same time points to the conclusion that the soil may be duly infected for the growth of some descriptions of plants, but not for some other descriptions. Moreover, land which is, so to speak, quite exhausted so far as the growth of one leguminous crop is concerned, may still grow very luxuriant crops of another description of the same order, but of different habits of growth, and especially of unlike character and range of roots.

Not only the facts ascertained in the Rothamsted experiments and in other investigations, but also the history of agriculture throughout the world, so far as it is known, clearly show that a fertile soil is one which has accumulated within it the residue of long periods of previous vegetation, and that it becomes infertile as this residue is removed. That this exhaustion proceeds slowly may be gathered from the fact that wheat has been grown at Rothamsted for more than fifty years in succession on the same land, and, setting aside fluctuations due to season, the produce has only been reduced by an average of about one-sixth bushel per acre per annum, due to exhaustion. Without any manure whatever, the average annual produce for over fifty years was thirteen and a half bushels—a yield exceeding the average of the United States under ordinary cultivation, including their rich prairie lands, and about the average of the whole world. The accompanying table shows that with farmyard manure the average annual produce over the fifty years of continuous growth was thirty-three and a half bushels—a result not far short of three times the average produce of the United States and more than two and a half times the average of the whole of the world.

Averages.	14 Tons Farmyard Manure every Year.	Without Manure every Year.	Mixed Mineral Manure alone.	Ammonium Salts alone.
	Bushels.	Bushels.	Bushels.	Bushels.
8 years, 1852-59 ...	34¾	16¾	19	32¾
8 years, 1860-67 ...	35¾	13¾	15¼	31¼
8 years, 1868-75 ...	35¾	12¾	14	28¼
8 years, 1876-83 ...	28¾	10¾	12¾	27¾
8 years, 1884-91 ...	39¼	12¾	13¾	32¼
20 years, 1852-71 ...	35¾	14¼	17	31¼
20 years, 1872-91 ...	33¼	11¼	12¾	29¼
40 years, 1852-91 ...	34¼	13	15	30¼
50 years, 1844-93 ...	33¼	13¼	—	—

Artificially manured plots show that mineral manures alone gave very little increase of produce; that nitrogenous manures alone gave considerably more than mineral manures alone; but that mixtures of the two gave very much more than either separately. An inspection of the following table of results, as indicating the amounts of produce in the best and in the worst seasons of the forty years, will show how easy it is to form wrong conclusions as to the effects of different manures if experiments are conducted for one season only, or in only a few seasons, and if the characters of the seasons are not studied and due allowance made accordingly in drawing inferences from results obtained.

Thus it will be seen that all the plats suffered severely in the bad season. Compare columns *a* and *b*. In most cases (see columns *c* and *d*) the difference between the produce of the best and the worst season approached, and in two cases actually exceeded, the average produce of the plats.

WHEAT YEAR AFTER YEAR ON THE SAME LAND.

Produce of the best season, 1863; of the worst season, 1879; and the average of forty years, 1852-1891.

Description of Manures (Quantities per Acre).	Dressed Grain (per Acre). Best Season, 1863.	Worst Season, 1879.	Difference.	Average, 40 years, 1852-91.
	Bushels. *a.*	Bushels. *b.*	Bushels. *c.*	Bushels. *d.*
Unmanured	17¼	4¾	12½	13
Farmyard manure	44	18	26	34½
Mixed mineral manure alone ...	19¼	5¼	14	15
Mixed mineral manure and 200 pounds ammonium salts = 43 pounds nitrogen	39½	10½	29	24½
Mixed mineral manure and 400 pounds ammonium salts = 86 pounds nitrogen	53½	16½	37	33½
Mixed mineral manure and 550 pounds nitrate soda = 86 pounds nitrogen	55½	22	33½	35½
Mixed mineral manure and 600 pounds ammonium salts = 129 pounds nitrogen	55½	20½	35½	36½

More than two thousand years ago the Romans recognized the fact that leguminous crops enriched the soil for succeeding crops—in short, discovered what is termed the "rotation of crops," a practice which is admitted to be the foundation of the improvements in our own agriculture. How, then, are the admittedly beneficial effects of alternate as distinguished from continuous cropping to be explained? Liebig's first definite theory on this subject assumed that the excreted matters of one description of crop were injurious to plants of the same description, but that they were not so, and might even be beneficial, to other kinds of plants.

Later he considered that, as the different plants had such diverse mineral requirements, the alternation of one kind with another relieved the soil from exhaustion, and discerned after many years that nitrogen probably played some important part in the matter. Boussingault, in chemical statistics extending over ten years, came to the conclusion that the difference in the amounts of nitrogen taken up by various crops constituted a very important element in the explanation of the benefits of rotation.

Prof. Daubeny, of Oxford, in testing De Candolle's theory that the excretions of one kind of plant were injurious to plants of the same description, arrived at a negative conclusion, and recognized the validity of Boussingault's argument that the same kind of plant may continue to grow healthier on the same land for long periods of time; and experience at Rothamsted also is conclusive against the theory of injurious or poisonous excretions. Upon the whole, the results at Rothamsted show that the benefits of rotation are very various.

The opportunities which alternate cropping affords for cleaning the land constitute a prominent element of advantage. The difference in the amounts available within the soil of the various mineral constituents is one element in the explanation; but the facts relating to the amount and to the sources of the nitrogen of the different crops are of still greater significance. The varying requirements of the different crops, habits of growth, and capabilities of gathering and assimilating the necessary constituents have to be considered; with a variety of crops the mechanical operations of the farm, involving horse and hand labor, are better distributed over the year, and are, therefore, more economically performed.

GUTTA PERCHA AND INDIA RUBBER.

BOTANISTS who are interested in the cultivation of Sapotaceæ on a commercial scale are beginning to realize the consequences of the careless methods that have denuded the Indo-Malayan regions of Taban trees. Cable manufacturers complain very seriously of the great fallingoff in quality of gutta percha during the past few years, and the small hope of obtaining better supplies in future. This degeneration of the cultivating industry is beginning to make itself felt in the Treasury reports of the gutta percha producing coun-

tries; not so much in the quantity annually shipped as in the prices paid for a given weight each year.

For instance, the Sarawak (Borneo) treasury report of revenue and expenditure for 1897 gives comparative figures relating to the condition of supply and demand of gutta percha and India rubber. The following table, drawn up from the report, shows the fall in prices of gutta percha during the four years 1894–1897, inclusive, and indicates a corresponding degradation of quality. (The "picul" is, for our purpose, taken as 133⅓ lb., and the Sarawak dollar as 1s. 11d.)

GUTTA PERCHA EXPORTED FROM SARAWAK.

Year.	Quantity.		Value.			Average price per picul.			
	Piculs.	Tons.	$	£	s. d.	$	£	s.	d.
1894	1937	115·3	162,233	15,547	6 7	83.75	8	0	6¼
1895	2782	165·6	194,130	18,603	3 4	69.77	6	13	8¾
1896	2820	167·9	190,939	18,298	6 5	67.70	6	9	9
1897	2867	170·7	185,532	17,780	3 0	64.71	6	4	0¼

With this may be compared the increased demand for and steady value of India rubber throughout the same period.

INDIA RUBBER EXPORTED FROM SARAWAK.

Year.	Quantity.		Value.			Average price per picul.			
	Piculs.	Tons.	$	£	s. d.	$	£	s.	d.
1894	1259	74·9	85,775	8,220	2 1	68.12	6	10	6¾
1895	1392	82·8	95,493	9,151	8 3	68.60	6	11	5¾
1896	1624	96·7	108,813	10,427	18 3	67.00	6	8	5
1897	2130	126·8	146,229	14,013	12 3	68.65	6	11	7

From another source we are able to give the total weights of gutta percha landed in England, from all gutta percha producing countries, since 1895.

TOTAL WEIGHT OF GUTTA PERCHA LANDED IN ENGLAND.

Year.	Tons.
1895	716
1896	318
1897	396
January to April, 1898	626

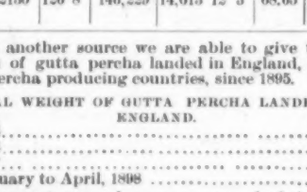
The present year shows a very marked rise in the demand for gutta percha. This is more apparent when it is remembered that the 626 tons was all landed between January 1 and April 30, and that the quantity landed in April alone was 149 tons.

We may sum up the condition of the gutta percha cultivation industry in a few words. There is an increasing demand, a degeneration of quality, and an almost total disregard of the future. Experimental efforts have, we believe, been made to produce a steady supply of high quality gutta percha, but so many years are required to establish the scheme on a profit-earning basis, that it is almost beyond the powers of private enterprise to make it a success.

We are indebted to Nature for the article.

JAPANESE ARRANGEMENT OF FLOWERS.

THE Japanese are justly famous for their skillful arrangement of flowers, by which the poorest of blooms



JAPANESE ARRANGEMENT OF FLOWERS.

are made to look their best, by being so displayed that their full beauty can be appreciated. Most of these good effects are produced by placing the flowers very sparsely in bamboo tubes, no attempt at a crowded bouquet being ever made. Some of the bamboos are familiar to us by this time, but, strange to say, they have been more widely adopted by milliners for the display of their artificial blooms than by those who are clever at the disposal of the natural blossoms. Perhaps one reason for this is, that after a time, the tubes are apt to leak, and their owners have not enterprise enough to get a small glass or zinc lining made to slip inside them to hold the water.

The latest importation from Japan for the purposes of floral decoration consists merely of a long strip of lead, which is crinkled and crumpled up into as many folds and flutings as possible (see illustration). These crumples must be so managed as not to interfere at all with the firm base, which enables the lead to stand steadily at the bottom of a bowl or basin. The flutings form a series of miniature tubes, into which the stems of the flowers are pushed, and which can be easily pinched or enlarged, as the slimness or thickness of the stems require. The flowers should on no account be crowded; and, of course, the higher they stand up above the edge of the bowl, the more graceful will they look. Not infrequently the lead is placed in the center of a large bowl, the water in which is allowed to be seen all round the flowers, and is supposed to give a cool look to the decoration. A miniature pond may readily be produced in this way, with small sedges, grasses, butomus, or herb trinity. The leaden ribbons vary somewhat in size; some are silvered, others are left in the natural color of the metal. Those who are skilled in the art of arranging flowers should feel an interest in trying experiments, and gaining fresh effects, by the help of this very simple contrivance.—The Gardeners' Chronicle.

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